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NATIONAL DAM SAFETY PROGRAM. LAKE LENAPE DAM (NJ00450), ATLANTI--ETC(U)
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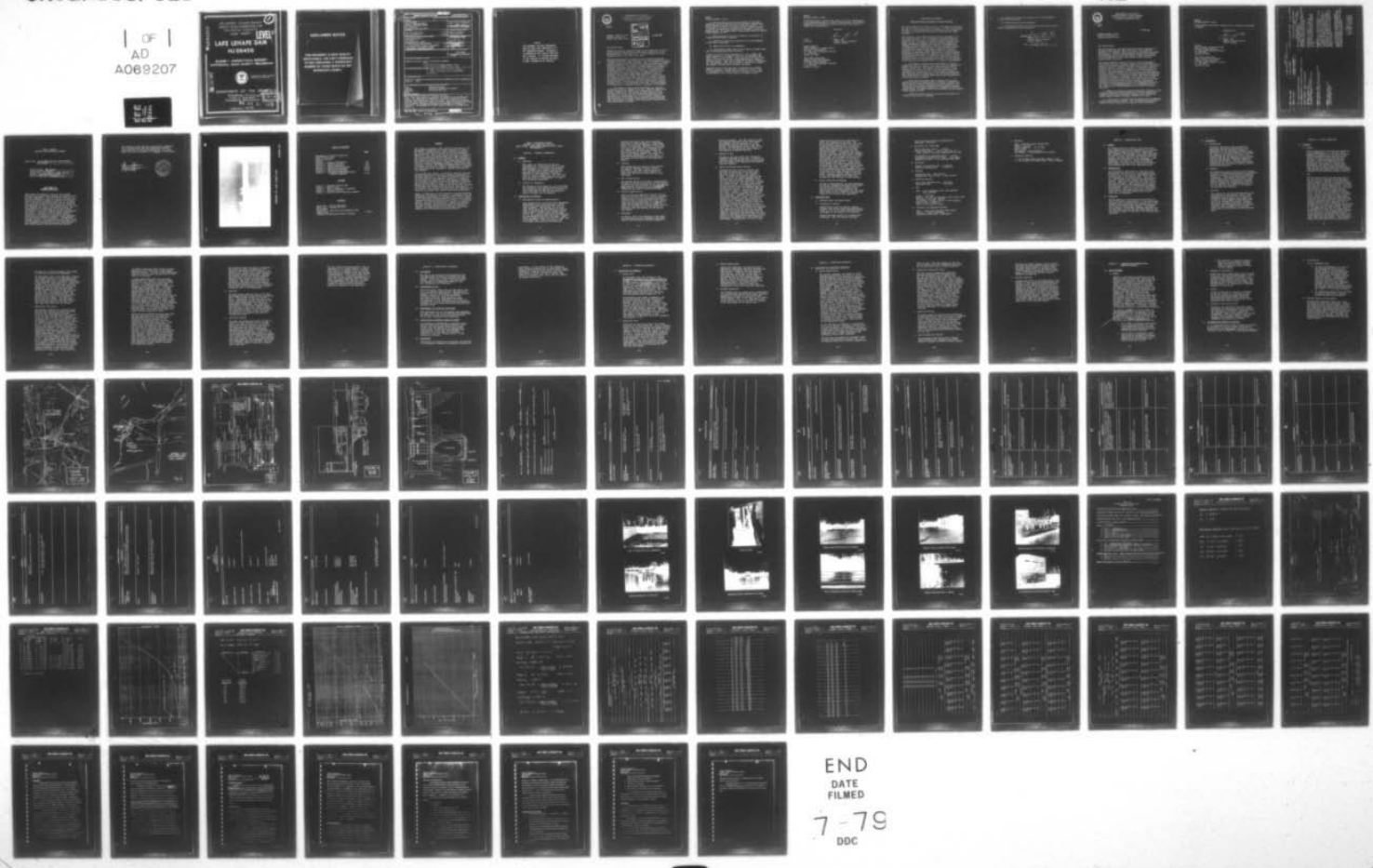

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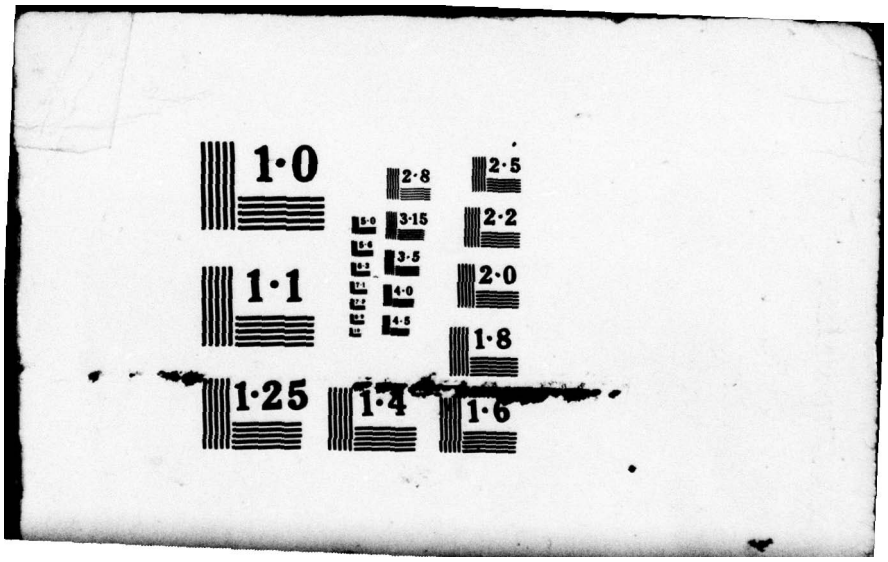
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ATLANTIC COAST BASIN
GREAT EGG HARBOR RIVER
ATLANTIC COUNTY
NEW JERSEY

LEVEL II

LAKE LENAPE DAM

NJ 00450

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DEPARTMENT OF THE ARMY

Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

February, 1979

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NJ00450
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): Phase I Inspection Report
National Dam Safety Program
Lake Lenape Dam
Atlantic County, New Jersey

5. TYPE OF REPORT & PERIOD COVERED: (9) FINAL rept.,
6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s): (10) F. Keith Jolls, PE

8. CONTRACT OR GRANT NUMBER(s): (15) DACW61-78-C-0124

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Louis Berger & Assoc.
100 Halstead St.
East Orange, N.J. 07019

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: (12) 77p.

11. CONTROLLING OFFICE NAME AND ADDRESS
U.S. Army Engineer District, Philadelphia
Custom House, 2d & Chestnut Streets
Philadelphia, Pennsylvania 19106

(11) 12. REPORT DATE: Feb[illegible]79
13. NUMBER OF PAGES: 81

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

(6) National Dam Safety Program. Lake Lenape Dam (NJ00450), Atlantic Coast Basin, Great Egg Harbor River, Atlantic County, New Jersey. Phase 1 Inspection Report.

17. DISTRIBUTION STATEMENT (of the abstr

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dams
Spillway
Foundation
Safety
Visual Inspection
Structural Analysis
National Dam Inspection Act Report
Lake Lenape Dam, N.J.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT CORPS OF ENGINEERS
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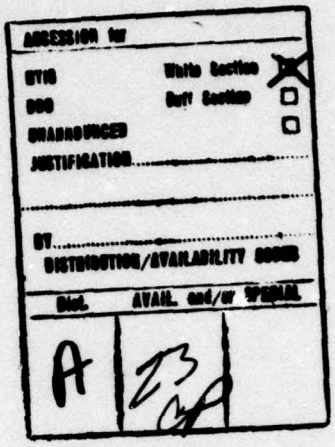

15 MAY 1979

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Lake Lenape Dam in Atlantic County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Lake Lenape Dam, a high hazard potential structure, is judged to be in fair overall condition. Also, the spillway is considered seriously inadequate since 16 percent of the Probable Maximum Flood (PMF) would overtop the dam. The seriously inadequate spillway is assessed as an UNSAFE, non-emergency condition, until more detailed studies prove otherwise or corrective measures are completed. The classification of UNSAFE applied to a dam because of a seriously inadequate spillway is not meant to indicate the same degree of emergency as would be associated with an UNSAFE classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam could take place, significantly increasing the hazard to loss of life downstream from the dam. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant, engaged by the owner, using more sophisticated methods, procedures and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. Within six months from the date of approval of this report, engineering studies and analysis should be performed to determine the dam and spillway foundation condition and structural stability. This should include test borings to determine material properties relative to stability and seepage and installation of piezometers to facilitate seepage studies. Any remedial measure found necessary should be initiated within calendar year 1980.

c. Within six months of the date of approval of this report, the following actions should be completed:

(1) Regrade and provide slope protection for the east embankment to the left of the spillway.

(2) Remove trees from the east embankment.

(3) The downstream channel below the apron should be further stabilized to provide additional scour protection.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman William J. Hughes of the Second District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

NAPEN-D
Honorable Brendan T. Byrne

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N. J. Dept. of Environmental Protection
P. O. Box CN029
Trenton, NJ 08625

John O'Dowd, Acting Chief
Bureau of Flood Plain Management
Division of Water Resources
N. J. Dept. of Environmental Protection
P. O. Box CN029
Trenton, NJ 08625

LAKE LENAPE DAM (NJ00450)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 5 December 1978 by Louis Berger and Associates, Inc. under contract to the State of New Jersey. The State, under agreement with the U. S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Lake Lenape Dam, a high hazard potential structure, is judged to be in fair overall condition. Also, the spillway is considered seriously inadequate since 16 percent of the Probable Maximum Flood (PMF) would overtop the dam. The seriously inadequate spillway is assessed as an UNSAFE, non-emergency condition, until more detailed studies prove otherwise or corrective measures are completed. The classification of UNSAFE applied to a dam because of a seriously inadequate spillway is not meant to indicate the same degree of emergency as would be associated with an UNSAFE classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam could take place, significantly increasing the hazard to loss of life downstream from the dam. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant, engaged by the owner, using more sophisticated methods, procedures and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. Within six months from the date of approval of this report, engineering studies and analysis should be performed to determine the dam and spillway foundation condition and structural stability. This should include test borings to determine material properties relative to stability and seepage and installation of piezometers to facilitate seepage studies. Any remedial measure found necessary should be initiated within calendar year 1980.

c. Within six months of the date of approval of this report, the following actions should be completed:

(1) Regrade and provide slope protection for the east embankment to the left of the spillway.

(2) Remove trees from the east embankment.

(3) The downstream channel below the apron should be further stabilized to provide additional scour protection.

APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 4 May 1979

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN

21 FEB 1979

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

This is in reference to our ongoing National Program for Inspection of Non-Federal Dams within the State of New Jersey. Lake Lenape Dam (Federal I.D. No. NJ00450), a high hazard potential structure has recently been inspected. The dam is owned by Hamilton Township and the Wheaton Plastics Company and is located approximately 13 miles from the mouth of the Great Egg Harbor River at Mays Landing, Hamilton Township, Atlantic County, New Jersey.

Using Corps of Engineers screening criteria, it has been determined that the dam's spillway is seriously inadequate since approximately 16 percent of the Probable Maximum Flood would overtop the dam. The seriously inadequate spillway is assessed as an UNSAFE, non-emergency condition, until more detailed studies prove otherwise, or corrective measures are completed. The classification of UNSAFE applied to a dam because of a seriously inadequate spillway is not meant to indicate the same degree of emergency as would be associated with an UNSAFE classification applied for a structural deficiency. It does mean, however, that based on an initial screening and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard potential to loss of life downstream from the dam. As a result of this UNSAFE determination, it is recommended that the dam's owner take the following measures within 30 days of the date of this letter:

a. Engage the services of a qualified professional consultant to more accurately determine the spillway adequacy by using more detailed and sophisticated hydrologic and hydraulic analyses, and to recommend any remedial measures required to prevent overtopping of the dam.

b. In the interim, a detailed emergency operation plan and downstream warning system should be developed. Also, round-the-clock surveillance should be provided during periods of unusually heavy precipitation.

NAPEN-D
Honorable Brendan T. Byrne

A final report on this Phase I Inspection will be forwarded to you within two months.

Sincerely yours,

James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

Cy Furn:
Dirk C. Hofman, Actg Deputy Director
Division of Water Resources
N.J. Dept of Environmental Protection
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Trenton, NJ 08625

John O'Dowd, Acting Chief
Bureau of Flood Plain Management
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N.J. Dept of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

UNSAFE DAM
NATIONAL PROGRAM OF INSPECTION OF DAMS

a. NAME: Lake Lenape

b. ID NO.: NJ 00450

c. LOCATION State: New Jersey County: Atlantic
River or Stream: Great Egg Harbor River
Nearest D/D City or Town: Mays Landing

d. HEIGHT: 29 Feet

e. MAXIMUM IMPOUNDMENT CAPACITY: 6,300 ac. ft.

f. TYPE: Earth with masonry spillway

g. OWNER: Wheaton Plastics Co. and Hamilton Township

h. DATE GOVERNOR NOTIFIED OF UNSAFE CONDITIONS: 21 Feb 79

i. CONDITION OF DAM RESULTING IN UNSAFE ASSESSMENT
Preliminary report calculations indicate 16% of PMF would overtop the dam.

l. URGENCY CATEGORY: UNSAFE, Non-Emergency

m. EMERGENCY ACTIONS TAKEN:
Gov. notified of this condition by District Engineer's 21 Feb 79 letter

j. DESCRIPTION OF DANGER INVOLVED:
Overtopping and failure of the dam significantly increases hazard potential to loss of life and property downstream of dam.

n. REMEDIAL ACTIONS TAKEN: N.J.D.E.P. will notify dam's owner upon receipt of our letter.

k. RECOMMENDATIONS GIVEN TO GOVERNOR:
Within 30 days of date of District Engineer letter the owner do the following:
a. Engage the services of a qualified professional consultant to more accurately determine the spillway adequacy by using more detailed and sophisticated hydrologic and hydraulic analyses, and to recommend any remedial measures required to prevent overtopping of the dam.

b. In the interim, a detailed emergency operation plan and downstream warning system should be developed. Also, round-the-clock surveillance should be provided during periods of unusually heavy precipitation.

o. REMARKS: Final report, to be issued within six weeks, will have WHITE cover.

W. R. Zink 2/22/79
W. R. ZINK, Coordinator
Dam Inspection Program
U.S.A.E.D., Philadelphia

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam Lake Lenape Dam Fed. ID# NJ 00450, NJ ID# 645

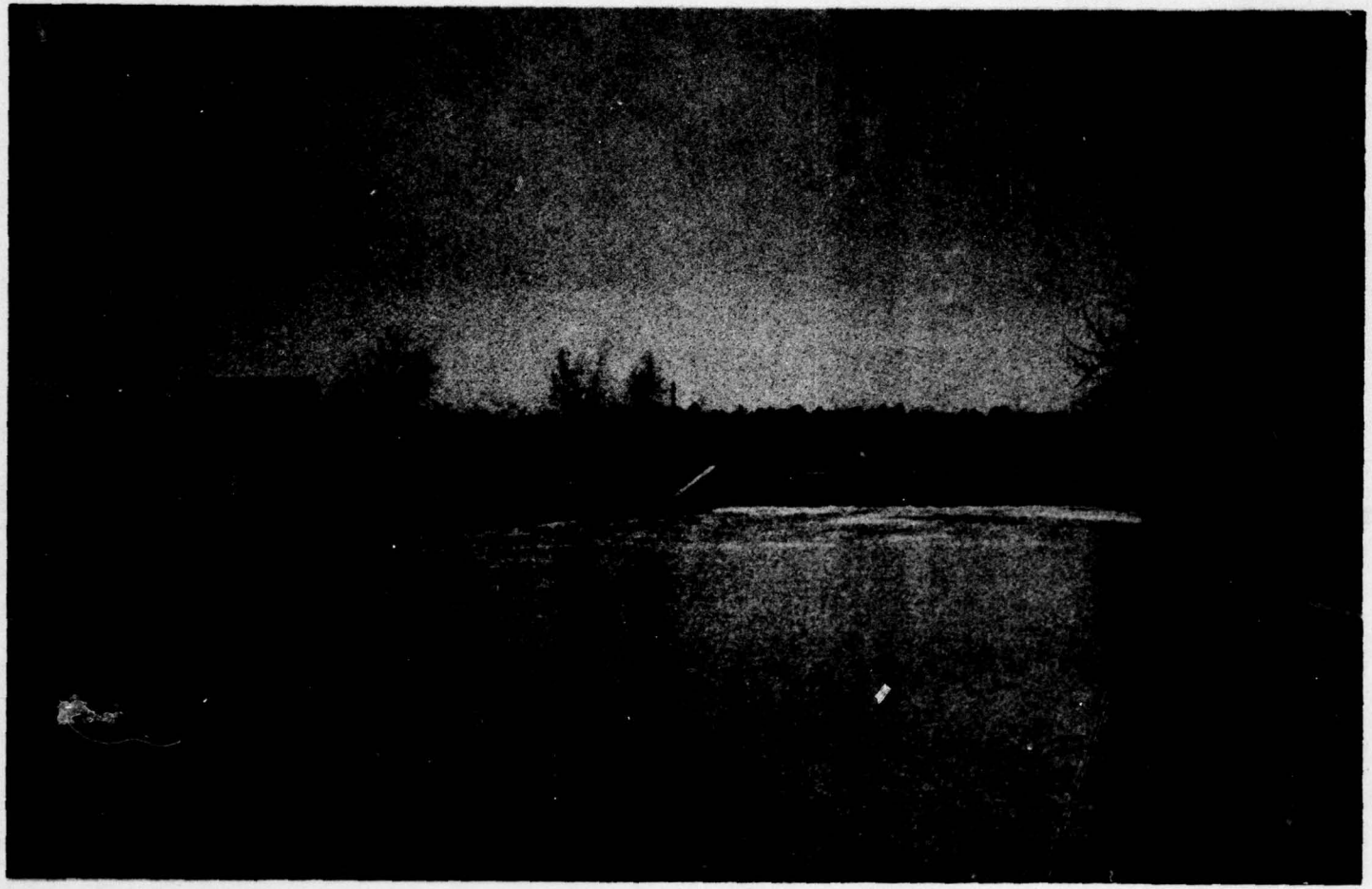
State Located New Jersey
County Located Atlantic
Coordinates Lat. 3927.3 - Long. 7443.6
Stream Great Egg Harbor River
Date of Inspection 5 December 1978

ASSESSMENT OF GENERAL CONDITIONS

Lake Lenape Dam appears to be in a fair overall condition but considerable seepage was observed along the east embankment. The dam is over 90 years old and has withstood the test of time but has been overtopped with serious damage as recently as 10 years ago. Sufficient engineering data was not available regarding the spillway foundations or the zoning of the embankment to allow a full assessment of the long-term adequacy and further engineering studies are recommended to be undertaken in the near future (although the spillway underwent major reconstruction last year). Included in these studies should be geotechnical investigations including material properties and piezometer readings of the embankment and underlying foundation material. Recommended remedial actions to be undertaken in the near future include regrading and protecting the backslope of the east embankment and removing of the trees thereon, and further stabilizing the downstream channel.

The capacity of the spillway is seriously inadequate as it is determined that the embankment would be overtopped for all storms exceeding 15% of the PMF; hence, the dam is adjudged to be UNSAFE, non-emergency.

F. Keith Jolls P.E.
Project Manager



OVERVIEW OF LAKE LENAPE DAM

DECEMBER 1978

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
NAME OF DAM: LAKE LENAPE DAM FED ID# NJ 00450, NJ ID# 645

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority

This report is authorized by the Dam Inspection Act, Public Law 92-367, and has been prepared in accordance with Contract FPM-36 between Louis Berger & Associates, Inc. and the State of New Jersey and its Department of Environmental Protection, Division of Water Resources. The state, in turn, is under agreement with the U.S. Army Engineer District, Philadelphia, to have this inspection performed.

b. Purpose of Inspection

The purpose of this inspection is to evaluate the structural and hydraulic condition of the Lake Lenape Dam and appurtenant structures, and to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances

Lake Lenape Dam is a very old earth embankment approximately 1050 feet long with a stone masonry spillway located 220 feet from the right abutment. The spillway is 124 feet wide and is about 500 feet directly upstream from a highway bridge on Mill Street (State Highway 40). Located within the spillway are 3 - 48" concrete pipes that are controlled by hand operated vertical lift gates. These pipes are approximately 30' from the right end of the spillway. There are also 2 - 24" inlet pipes controlled by hand-operated

vertical lift gates that were originally installed to feed turbines in a powerhouse built atop the right embankment (now inoperative). In addition, there is a 4 foot wide "ice gate" that controls a sluiceway which was originally installed for breaking up the surface ice at the damface. The ice chute is presently stopped up to pond level with timber flashboards. A low timber bulkhead extends downstream from the spillway along the left bank of the downstream channel.

b. Location

Lake Lenape Dam is located at Mays Landing in Hamilton Township, Atlantic County, New Jersey. The dam is built across the Great Egg Harbor River approximately 13 miles from the mouth of the river at Great Egg Harbor.

c. Size Classification

The maximum height of the dam is approximately 29 feet and the maximum storage is 6610 acre-ft. Therefore the dam is placed in the intermediate size category as defined by the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification

Based on Corps of Engineers criteria and the fact that in the event of a failure, excessive damage could occur to downstream properties together with a sizable potential for loss of life, the dam is classified as a high hazard. Immediately downstream there are numerous homes and the Wheaton Plastics Company factory. These are situated over 10 feet below the spillway crest and directly in the path of any floods.

e. Ownership

On July 4, 1978, the ownership of the spillway structure and left embankment was transferred from the Wheaton Plastics Company to

Hamilton Township. The lake itself is under the separate ownership of the Lake Lenape Land Company but the Township is in the process of acquiring the deed to the lake bottom. The embankment to the right of the spillway (in the powerhouse area) remains the property of Wheaton Plastics.

f. Purpose of Dam

The dam is now used solely for recreation purposes, although in the past, it served as a power intake containment for earlier cotton mill facilities (now occupied by the Wheaton Plastics Company).

g. Design and Construction History

Although the exact date is unknown, the original structure was built well before the turn of the century. The original works is thought to have been rebuilt in 1879. In 1920, the present powerhouse was constructed on the right embankment about 100 feet from the present spillway to provide electricity for the cotton mill located just below the dam. For some prior period, an auxiliary canal ran southward into the factory building area and provided some type of mechanical energy. In 1973 the lake was dewatered to allow an inspection to be made for leaks. However, no major problem areas were observed and consequently no repairs were performed. However, according to a 1975 consulting engineer's report, an underwater inspection revealed that the integrity of the dam was in jeopardy. Wheaton Plastics Company, owner of the dam at that time, was advised to immediately drawdown the lake. A subsequent visual examination revealed all three 48" cast iron pipes beneath the spillway had numerous cracks and the rock and timber crib apron below the spillway was severely damaged. The continuous discharge from the pipes had apparently scoured a deep (40± feet) cavity in the downstream riverbed and a major portion of the timber apron was completely demolished. Consequently, in 1977, a major

reconstruction program was undertaken to repair and rehabilitate the dam. The cast iron pipes were removed from each side of the existing masonry wall and new 48" reinforced concrete pipes were installed. After final positioning, a 4 foot mass concrete encasement was poured over and around the pipes. A compacted clay embankment was installed upstream from the masonry spillway wall over its full width. On the outlet side, the streambed was backfilled with quarry-run rock and a 4 foot thick concrete apron was poured over the top of the existing timber piling. Additionally, a new catwalk and timber supported control platform were built to provide better access to the sluice gates controls. Additional fill was placed along the embankment sections of the dam and riprap slope protection was installed at the toes of slope in certain areas. However, minimal repairs were made to the east embankment area except for placing new fill adjacent to the spillway.

h. Normal Operating Procedures

The dam is maintained by the Road Department of Hamilton Township who operate the adjustable gates and monitor the lake level. Wheaton Plastics retains operation and maintenance of west embankment but the powerhouse intakes and ice gate are normally not adjusted in the day-to-day operations.

1.3 PERTINENT DATA

a. Drainage Area: 205 Square Miles

b. Discharge of Damsite

Maximum known flood at damsite: unknown. (however the dam has been overtopped several times by 1 to 2 feet which would indicate a flood peak in the range of 9-11,000 cfs.)

Ungated spillway capacity at maximum pool elevation: 3000 cfs (without sluices)

Total spillway capacity at maximum pool elevation: 4000 cfs.

c. Elevation (ft. above MSL)

Top of dam (max. pool) - +16.0+
Design flood pool - +16.25 (1977 Div. of Water Quality and Supply Application No. 645)

Recreation Pool (spillway crest) - +11.81
Streambed at centerline of dam - -3.5+ (Avg.)
Maximum Tailwater - +7.0± (Extreme High Tide)

d. Reservoir

Length of recreation pool - 11,000 ft.
Length of maximum pool - 19,000 ft.

e. Storage

Recreation pool - 4500 acre-ft.
Maximum pool (Top of dam) - 6,610 acre-ft.

f. Reservoir Surface

Top of dam (Maximum pool) - 746 acres
Recreation pool - 300 acres

g. Dam

Type - earth embankment with stone masonry wall spillway

Length - 1050 feet
Height - 29± feet (at spillway; total struc. hgt.)
Top width - 18± feet (varies)
Side slopes - varies (1.5±:1); very irregular
Zoning & Core - Unknown
Core & Grout Curtain - None

h. Diversion and Regulating Tunnel

Type - 4 foot wide ice gate (open chute)
Closure - timber flashboards
Regulating facilities - inoperative

i. Spillway

Type - straight narrow crested weir
Length - 124 feet
Crest elevation - +11.81 (MSL)
Gates - None
U/S Channel - main reservoir
D/S Channel - G. Egg Harbor River channel

j. Regulating Outlets

3 - 48" Ø pipes below spillway (invert -1.7+)
2 - 24" Ø pipes into power house (invert unknown)

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No original design or contract plans were available; however a partially complete set of drawings prepared by Lippincott Engineering Associates were reviewed. (See Figures 2-5). These indicated the results of an underwater inspection conducted in 1977 (at which time much was learned about the geometry and construction of the spillway). This resulted in the remedial repairs subsequently undertaken. As there is a history of repairs being made as early as 1879, the original design most probably was done on an empirical basis.

2.2 CONSTRUCTION

As the earliest construction at this site took place before the above date, no information was available as to the source of embankment material or the nature of the masonry work. Until the 1977 dewatering and reconstruction, the spillway wall was thought to be concrete and faced with masonry. This proved incorrect when the rebuilding was undertaken. Additionally, there are no available records of the modification in embankment geometry or details of the 1920 powerhouse construction. There is a portion of a partially filled power canal immediately below the powerhouse but its original configuration or use could not be determined.

2.3 OPERATION

The dam appears to have operated satisfactorily since its initial construction. In the early days, the power canal diverted flow into and thru a side channel which passed under the factory buildings. (No traces of this channel remain). The power house appears to have been operated satisfactorily for many years but has not been used recently and the turbines appear to have been, for the most part, abandoned.

2.4 EVALUATION

a. Availability

Sufficient engineering data, especially concerning the zoning and make-up of the embankment and the underlying spillway foundations is not available to fully assess the design of the dam or determine its safety. The presence (or absence) of a core, the relative density and permeability are suspect although the dam has withstood a hydraulic head for many decades. The best source of information are the 1977 construction photographs presently retained by Wheaton Plastics engineering personnel.

b. Adequacy

The engineering data relating to the spillway structure is considered inadequate to completely assess its overall stability with sufficient reliability. Nothing is known regarding the foundations of the masonry crestwall. Additional geotechnical information, including material properties and piezometer readings will be required for complete evaluation as will be the type and nature of the foundations beneath the spillway.

c. Validity

The validity of the 1977 reconstruction data available is not questioned. Most of the recommendations put forth in the May 1977 Lippincott report appear valid, especially in view of the subsequent inspections made during the construction period. However, the covert rationale upon which the report concludes that the spillway has an adequate factor of safety appears to be without valid basis in the opinion of the inspection team.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General

Visual inspections of the dam were conducted with representatives of Wheatons Plastic Company on December 5 and 6, 1978. Numerous construction photographs taken during the 1977-78 rebuilding of the spillway were reviewed. These presented an excellent overview of the true conditions of the spillway structure and how the work was prosecuted. The methods of construction and supervision control were discussed in light of the existing conditions encountered and afforded the inspection team an excellent overview of the spillway's present condition.

b. Dam

The dam crest is at an average elevation of 16± but the exact abutment locations were very difficult to discern as the embankment blends gradually into the surrounding terrain which has been considerably altered by regrading since its initial construction. Near the west abutment, Wheaton Plastics and its predecessors have constructed numerous plant facilities and in 1977 regraded and added fill in certain low areas south of the power house. As all of the ground floor elevations of the factory buildings are several feet below the dam crest, they are understandably concerned with the overtopping potential. The westerly embankment zone up to the spillway (which remains in their ownership) was reshaped in 1977 with a narrow berm constructed halfway down the backslope. Riprap was placed on the downstream toe and the berm. The top of embankment on this side is substantially wider than the 18 foot average width observed on the east side of the spillway and the upstream edge is stabilized with broken concrete riprap and has several trees along the water edge (see photographs). The powerhouse intake retaining walls and the power house

building are situated roughly in the middle of this side of the earth embankment.

The embankment east of the spillway, although it was also brought up to grade during the 1977 repair work, has a ill-defined rather steep backslope which is devoid of stabilizing ground cover or slope protection. There are numerous secondary-growth trees along the slopes and several low spots on the top of embankment near the left abutment where traffic depressions exist in the dirt road on the crest. Considerable seepage was observed along the downstream toe. The upstream face is partially protected from wave action by several large pieces of broken concrete riprap. The lake front has silted up along the upstream shore so that the water appears to be only a few feet deep along the front of the dam.

c. Appurtenant Structures

The spillway consists of a straight stone masonry wall overflow structure estimated to be 29 feet high which discharges directly into the downstream river channel. It is 124 feet long and has an exposed height of about 15 feet. The footing depth is unknown but it is believed that it may be founded on vertical timber piling similar to those installed under the downstream apron. The crest is about 5 feet wide and the exposed downstream masonry face is on a steep 1H:30V batter. The upstream face is completely blanketed by a riprap covered trapazoidal clay berm installed during the recent improvements. Earlier plans indicated the existence of a concrete wall in front of the stone masonry but when dewatered in 1977, this information was found to be in error. Consequently, the impervious clay core imparts a considerable bracing effect as the masonry wall, by itself, has dubious structural stability. The masonry is laid up of "ironstone", a type of local rock, possibly obtained in the bog-iron areas immediately to the north. The joints are

in diverse conditions with certain portions appearing to be laid up dry. Other areas have been parged. It could not be ascertained whether or not the wall was built all at one time or in sections.

A timber downstream apron was originally constructed on a system of vertical timber piling at 5 feet centers in each direction with 6" x 6" lagging and timber plank decking. This extended about 50 feet downstream from the masonry wall. A section of the apron immediately below the three spillway pipes had suffered the severest damage and was the area of the major 1977 repair work. The planking was partially destroyed and a 40 foot deep hole was scoured out in the downstream riverbed (due to the excessive outlet energy of the pipes). This area was repaired by dumping a large volume of broken stone into the cavity and rebuilding a 3 to 4 feet thick concrete slab over the stone in the areas where the timber decking was destroyed. It is unknown whether or not cavities still exist under areas where the timber planking remained in place.

Three new 48" reinforced concrete pipes and manually operated gates are installed on the upstream side of the spillway and connected with metal sleeves to the sections of undisturbed cast iron pipe which pass through the masonry wall. The entire area is encased in concrete and covered with the compacted clay blanket. The top width of this core was not determined but it is estimated to be roughly 20 feet. A new timber catwalk is installed from the east retaining wall to the flood gate controls. Finally, new concrete caps were poured in 1977 on the side retaining walls at either end of the spillway. The sand and gravel cofferdams utilized during this reconstruction were allowed to scour away naturally to help further stabilize the downstream channel.

The concrete intake structure to the powerhouse and ice chute are spalled at the waterline and exhibit minor cracking. The vertical lift sluices are in good condition, having been recently overhauled. However, the capacity of the two 24-inch discharge pipes and the ice chute are negligible insofar as the overall dam hydraulics are concerned. The crest of the ice chute is presently maintained with timber lagging. The concrete sidewalls are in fair condition, having been built integrally with the east foundation wall of the powerhouse.

d. Reservoir

The Lake Lenape reservoir has an old, well established shoreline with several residences and a lookout tower located on the east shore. Immediately to the west and to the north, the adjacent terrain consists of low-lying swampy marshlands with only minor development established. The reservoir is maintained at a relatively constant level and the banks in most areas slope gradually down from the shoreline to the center which is reported to be about 30 feet in depth. The reservoir is substantially clear of flotsam and jetsam.

e. Downstream Channel

The Great Egg Harbor River below the dam is subject to tidal effects with an average daily fluctuation of about 3.5 to 4 feet. Downstream from the dam about 500 feet is the three span Mill Street bridge and immediately to the south is the Wheaton Plastics Company property. To the left of the spillway discharge apron there is a low timber bulkhead which extends several hundred feet towards Mill Street. Nothing was known about the bulkhead but it is in fair condition and helps stabilize the downstream toe of the east embankment near the spillway. The top of its lagging appears to be just slightly above high tide.

The Mill Street bridge has about 3 feet of freeboard to its curved soffits at normal high tide but it appears that it could be quite easily overtopped as the top of deck is approximately 10 feet below the spillway crest elevation. Below Mill Street, the river has a clear channel approximately 100 feet wide which discharges into low-lying tidal marshlands over 1000 feet in width. A railroad trestle crosses the river further to the south but would have no hydraulic influence on the study dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The dam is now operated and maintained by the Road Department of Hamilton Township who have recently instituted a thorough system of safeguards. As set forth below, their procedures for operation and emergencies appear to be well thoughtout and formalized.

4.2 MAINTENANCE OF DAM

Since the recent repair work is less than a year old, no currently required major maintenance is envisioned by the municipality. Wheaton Plastics Company, (owners of the right embankment) continually maintain their portion of the structure with plant engineering personnel. The remainder is the responsibility of Hamilton Township but to date the maintenance has primarily consisted of daily inspections and monitoring the spillway flows.

4.3 MAINTENANCE OF OPERATING FACILITIES

Full responsibility for the sluice gate operation has been taken over by the Township Road Department who monitor the dam twice daily and maintain a log of water elevations and conditions.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

The Township has established a practical early-warning system with written procedures, daily contact with the Weather Bureau and 24-hour liaison with the operators of upstream dams. Life-jackets, radios and other equipment are supplied and in the event of high water conditions, the Civil Defense center in Mays Landing is notified.

4.5 EVALUATION

Maintenance and operational procedures are believed to be completely adequate as presently staffed and

programmed. In the opinion of the inspection team, Hamilton Township has an experienced, well-managed staff and are fully aware of their responsibilities. However, having only taken over responsibility within the last 6 months, they have yet to undergo their first test in a period of extreme heavy flow.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data

In accordance with the criteria in the Recommended Guidelines for Safety Inspection of Dams, it has been determined that the dam at Lake Lenape is intermediate in size and is placed in the high hazard category. Accordingly, the spillway design flood (SDF) was determined to be the probable maximum flood (PMF) by the inspecting engineer. The inflow hydrograph was calculated from the full probable maximum precipitation using data from Hydrometeorlogical Report No. 33.

As directed by the Corps of Engineers, the inflow hydrograph and flood routing were performed utilizing the HEC-1 computer program. Peak inflow to the reservoir for the full PMF was 27,510 cfs and, when routed, reduced insignificantly to 27,460 cfs. The total spillway capacity before overtopping occurs is approximately 4000 cfs. Therefore, the spillway will accommodate only 15% of the SDF. This flood would cause the dam to be overtopped by approximately 3.7 feet. The spillway is therefore seriously inadequate (see Section 7.1.a).

b. Experience Data

There are no long-term stream flow records available for Lake Lenape Dam. Local residents stated that the dam has been overtopped several times in the past, although the extent of overtopping information does not appear to be too reliable. In the inspection report prepared in 1977 by Lippincott Engineering Associates, a 100-year storm was calculated to have a peak discharge of 4000 cfs with a maximum flood elevation of +15.9 (with the sluice gates open). This would probably cause some overtopping at the low points of the embankment but would mostly be contained by the spillway and sluices.

c. Visual Observations

During the inspection, the spillway crest appeared in reasonable condition; however the main points of interest are the three 48" sluice gates. These are in good working order and are in use most of the time. At low heads over the crest, these sluices provide the bulk of the spillways capacity. However, due to the high exit velocities there is likely to be scour just below the downstream apron. This could not be verified due to the depth of water but substantial outlet velocities were observed.

d. Drawdown Potential

The drawdown time for Lenape Lake is controlled to a considerable degree by the tidal tailwater. Assuming no tailwater the lake would take approximately 6 days to draw down to the invert of the sluices. (El. -1.7) Some water would remain behind the dam as the lake is reported to be much deeper in its center area.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

The overall alignment and condition of the reconstructed spillway structure is fairly good and appears to be functioning adequately. Although the west Wheaton Plastics embankment is quite wide with well-grassed slopes partially protected with riprap, the easterly (left) embankment is felt to be of questionable quality, especially in the lower back slope areas. Certain portions of this were overtopped in the late 1960's and were extensively sandbagged to prevent further damage. Although a considerable amount of fill was added to the top of dam during the recent reconstruction, it remains in a fairly uneven condition and should overtopping occur, it is questionable whether the downstream back slopes would withstand any concentrated surface flows. Although most of the dam has been in place for 90 years, it is fairly certain that no stability analysis or flow network studies have even been undertaken for the embankment areas. There are numerous trees on the east backslope and surficial evidence of granular fill with little cohesive binder. There is severe sloughing in several areas that are completely void of protective ground cover. Some evidence of seepage was noted on the lower portions of the downstream slopes.

As the spillway was handling a considerable flow at the time of inspection, nothing could be viewed regarding its condition. As previously explained, the 1977 construction photographs were of excellent quality and gave the inspection team a cogent overview of the submerged portions when dewatered.

The concrete construction at the power house intake, although almost 60 years old, is in an adequate structural condition commensurate

with its age. The front portion of the ice gate is missing but the flashboards installed in the rear slots are in a solid condition.

b. Design and Construction Data

The 1977 reports prepared by Lippincott Engineering Company for Dam Application No. 645 indicated in their opinion that the dam was structurally stable for a 4 foot design head over the spillway. They correctly noted that an exact analysis was quite indeterminate and stability of the structure required the restraining effect of the timber and concrete downstream apron and the upstream clay blanket - all acting as an integral unit with the masonry wall. However, the wall alone has practically no factor of safety against overturning. As nothing is known regarding its underpinning, the overall long-term stability remains questionable and relies, in part, on the continued stability of the downstream apron. In view of the recent strengthening however, danger of collapse of the spillway is felt to be far less critical than the potential damage should the east embankment be overtopped and/or breached.

c. Operating Records

No formal operating records were located and nothing specific is known of earlier overtopping or failures (except the recent flood in late 1960). Numerous repairs and modifications have been made over the life of the dam, especially in 1920 when the old power canal into the factory area was filled in and the powerhouse erected. Judging from their condition, the concrete wingwalls on each side of the spillway could have been erected at that time.

d. Post Construction Changes

At the present time there are no further modifications being considered by either Hamilton Township or Wheaton Plastics Company

although the latter recently had an evaluation made regarding possible reactivation of the power house turbines. However, their engineers stated that, at the present time, it is economically unfeasible. The turbines appear to be very old and would require extensive overhauling.

e. Seismic Stability

Although the dam is in earthquake Zone 1 and thought to have negligible susceptibility to seismic forces, dynamic loadings should be included in further stability studies as a matter of record. The underlying foundation conditions is thought to consist mainly of Cap May formations of intermixed, unconsolidated marine deposits of silt, sand, clayey silt and clayey sand with some gravel layers at the shallower depths. Internal drainage is somewhat impeded by the silty-textured, lower soil strata but permeable gravel layers may occur at the shallower depths.

SECTION 7 - ASSESSMENTS/RECOMMENDATIONS/ REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety

Subject to the inherent limitations of the visual inspection procedures stipulated by the Corps of Engineers, the Lake Lenape Dam appears to be marginally adequate structurally for normally expected flood conditions although the spillway is seriously incapable of passing the design flood. The dam embankment and spillway foundations are built of unknown construction material and seepage was observed behind the east embankment. Overtopping of this area could erode the steep unprotected backslopes and possibly seriously breach the dam. No detrimental conditions were observed at the spillway to render a structurally inadequate assessment; however, the long-term stability remains extremely questionable until further studies are completed. In summary, the dam is adjudged to be in an overall fair condition.

The hydraulic capacity of the spillway is assessed as seriously inadequate as it has been determined that the embankment would be overtopped for all storms exceeding 15% of the full PMF and consequently, the dam is adjudged to be UNSAFE, non-emergency. Utilizing the Corps of Engineers criteria:

a. As a result of failure, there exists a high downstream hazard to human life, especially in the low-lying residential and manufacturing areas immediately below the dam.

b. Failure due to overtopping would significantly increase this hazard, especially in the Wheaton Plastics Company plant and the homes and stores along Mill Street.

c. The spillway is capable of passing only 15% of the probable maximum flood and therefore does not meet Corps of Engineers safety criteria in this respect.

b. Adequacy of Information

Except for visual observations and the review of the 1977 construction photographs, little information was otherwise available as no original design drawings exist and no recent surveys or inspections have been made. Performance data is believed to be nonexistent. The availability of information is therefore deemed to be inadequate.

c. Urgency

Further investigation should be undertaken in the near future as a collapse of this dam could irreparably damage downstream residences and manufacturing facilities and conceivably wash out the hydraulically inadequate Mill Street bridge.

d. Necessity for Further Study

Because of the structural stability cannot reasonably be ascertained with any reliance, the obtaining of additional information and the undertaking of further studies are recommended. Additional geotechnical investigations should include material property analyses and piezometer readings of the embankment and foundation material.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

It is recommended that further engineering studies be initiated in the near future as the dam is classified in the high hazard category and its spillway hydraulic capacity is seriously inadequate.

a. Alternatives

It is recommended that:

1) the east embankment to the left of the spillway be rebuilt up to a higher grade (to be determined in future studies) and the backslopes be regraded to a shallower slope. The trees should be removed and the slopes protected. Consideration could be given to constructing an auxiliary spillway at a higher elevation along the left embankment although such a solution would provide only partial hydraulic relief and possibly require the condemning of what appears to be private property.

2) the downstream channel below the apron be further stabilized to prevent renewed scouring of the channel.

b. O&M Maintenance and Procedures

No additional procedures other than those currently in effect are envisioned. However, the continued heavy flows through the three 48" pipes could conceivably again cause major scour damage to the downstream apron area. Further studies might reveal that these gates could be maintained in a closed condition a greater portion of the time. The more uniform flow over the spillway diminishes the concentrated energy dissipation in the downstream channel.

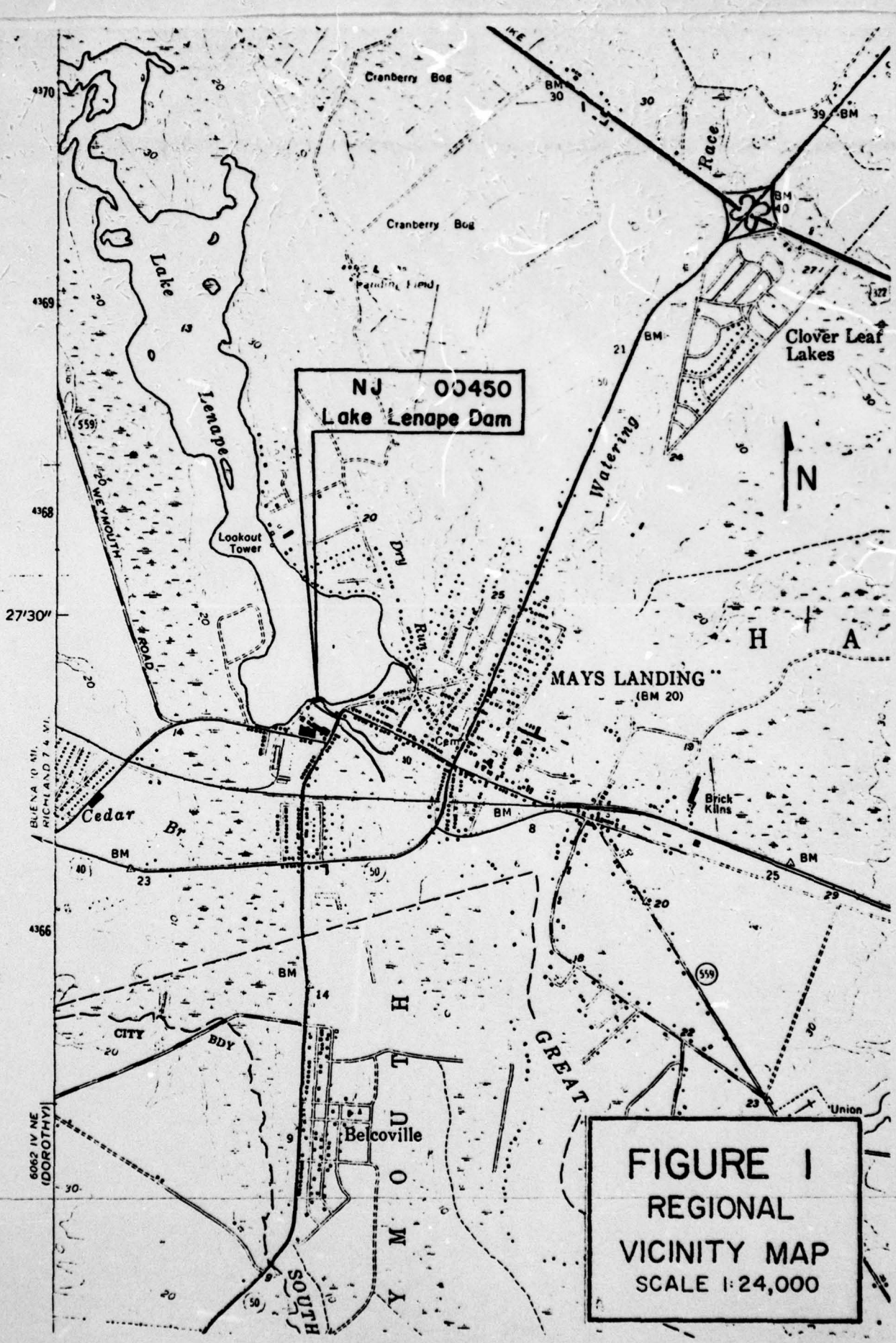
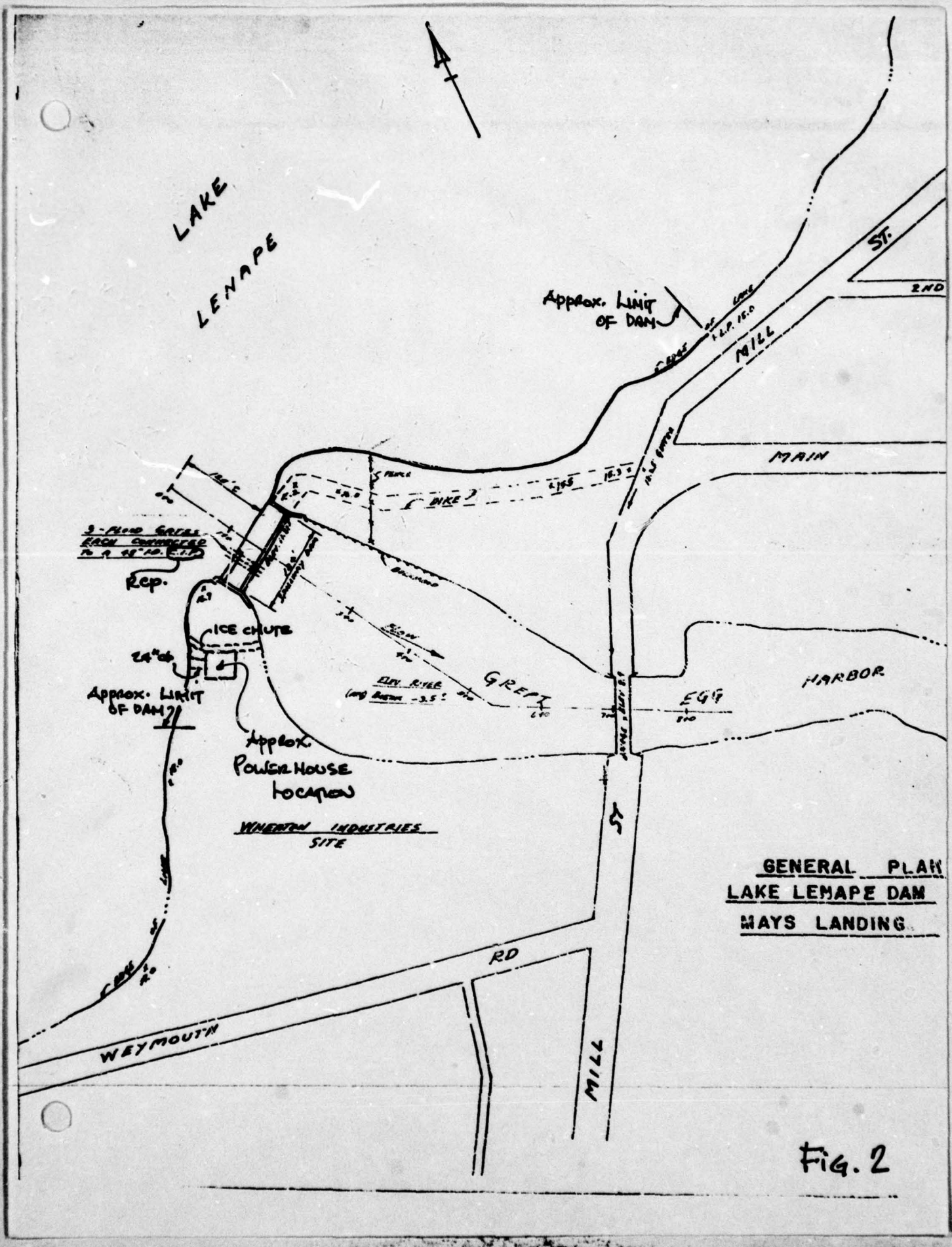


FIGURE 1
REGIONAL VICINITY MAP
SCALE 1:24,000



GENERAL PLAN
LAKE LEMAPE DAM
MAYS LANDING

Fig. 2

BY. D.L DATE 3-79

CHKD. BY DATE

LOUIS BERGER & ASSOCIATES INC.

SHEET NO. OF

PROJECT C226

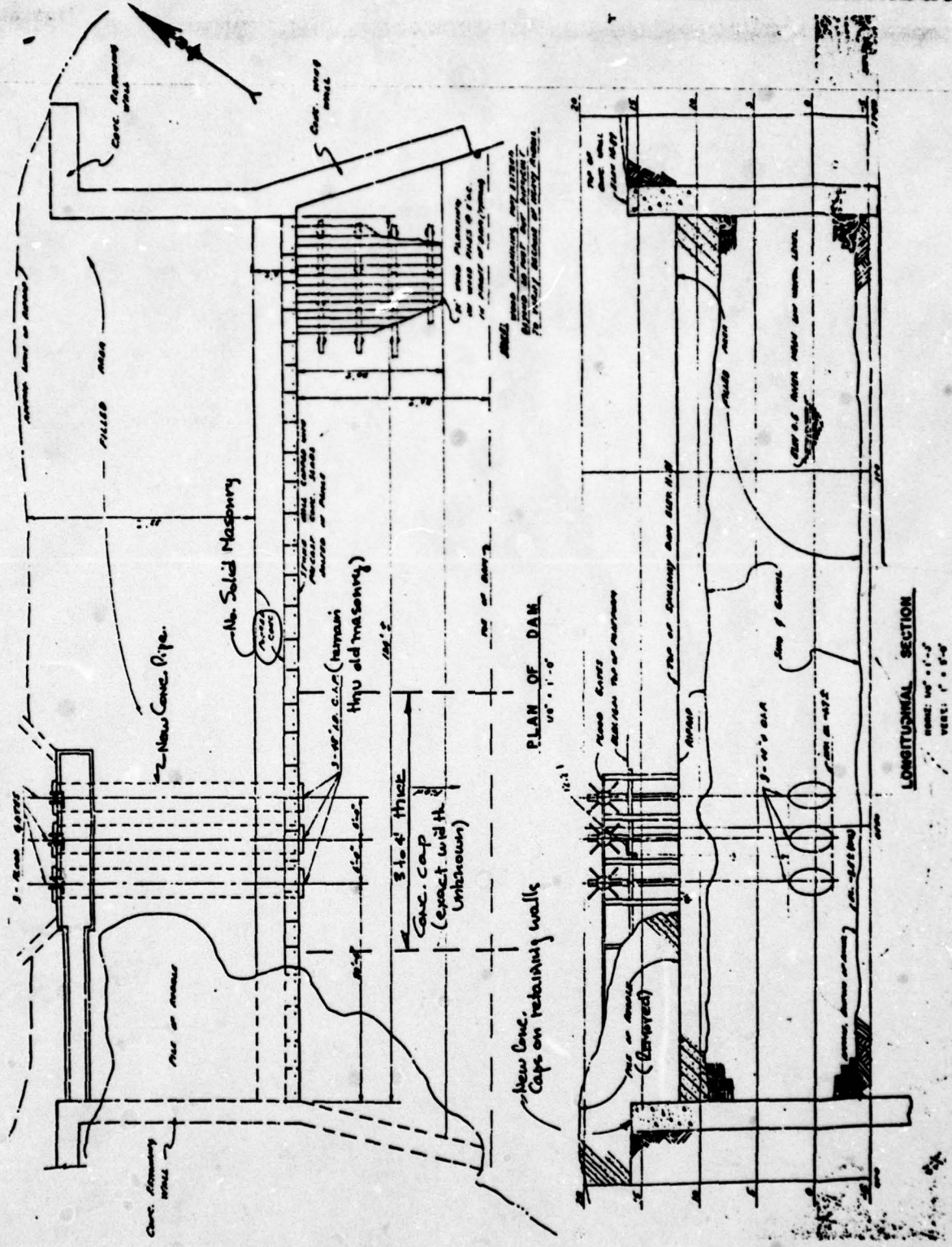


FIGURE 3
PLAN AND ELEVATION OF SPILLWAY

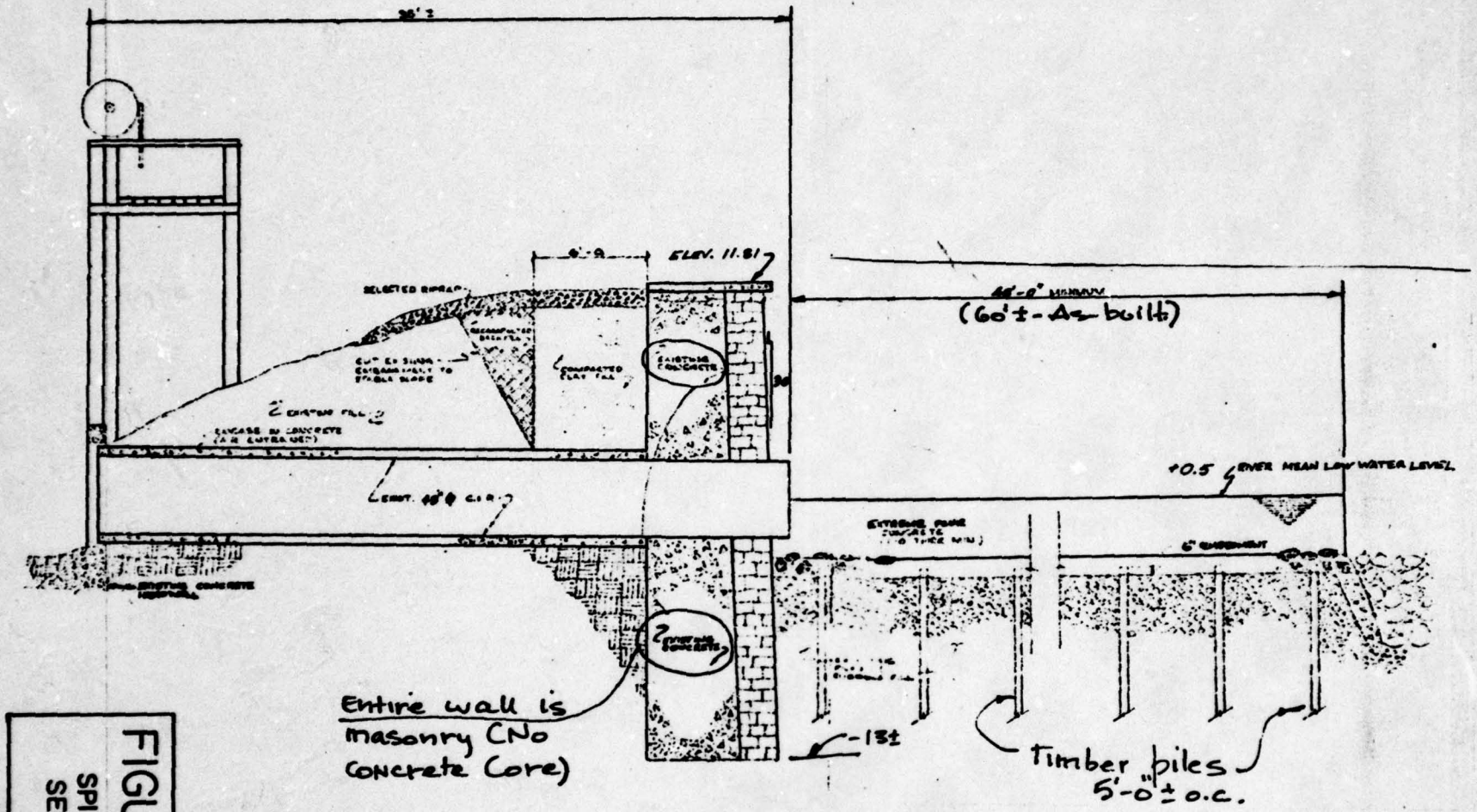


FIGURE 4
SPILLWAY SECTION

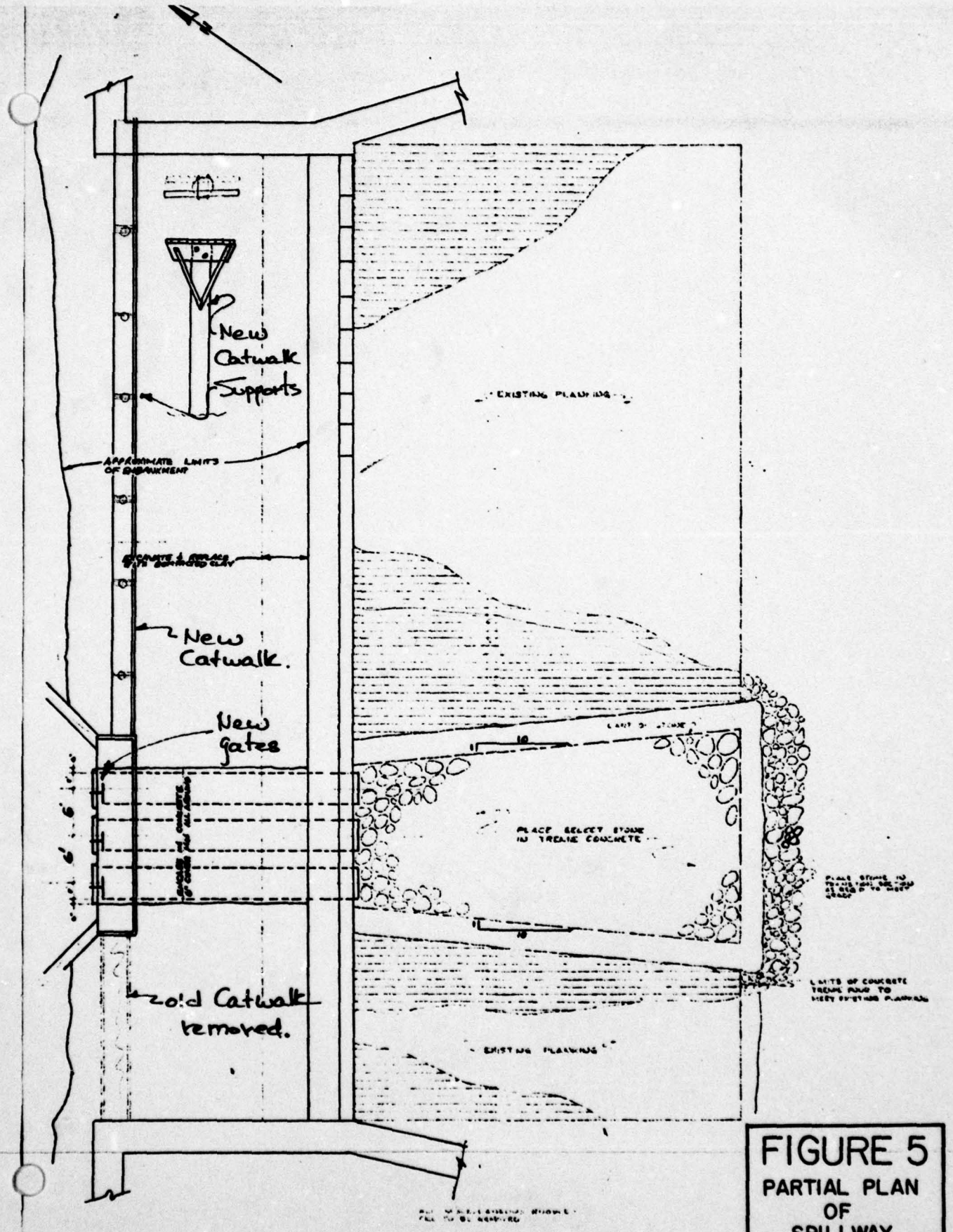


FIGURE 5
PARTIAL PLAN OF SPILLWAY CATWALK

ORIGINALS

Check List
Visual Inspection
Phase 1

Name Dam Lake Lenape Dam County Atlantic State New Jersey Coordinators NJDEP

Date(s) Inspection Dec. 5, 1978 Weather Cloudy Temperature 40°

Pool Elevation at Time of Inspection 13 ± M.S.L. Tailwater at Time of Inspection 3 ± M.S.L.

Inspection Personnel:

K. Jolls E. Simone

D. Lang /

M. Carter

K. Jolls Recorder

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEE PAGE ON LEAKAGE		
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Entire area very level No definite abutment junction	Right embankment ends just beyond old powerhouse Left embankment ends at low point near bend in road
DRAINS	None - Except for pipes through face of spillway wall.	
WATER PASSAGES	4' wide ice gate 2 - 24"ϕ sluicegates into powerhouse	
FOUNDATION	Unknown, possible timber piling, sand below Compacted clay embankment placed in excavated area above new pipes.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Spillway constructed of ironstone Lower portion is dry rubble masonry (as seen in reconstruction photographs) Upper portions show evidence of mortar and parging	
STRUCTURAL CRACKING	Wall at right end of spillway recapped and parged	
VERTICAL AND HORIZONTAL ALIGNMENT	Satisfactory on spillway	
MONOLITH JOINTS	None	
CONSTRUCTION JOINTS	None	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	To left of spillway	Backslopes steep with bad erosion.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Severe erosion on downstream face just left of spillway Evidence of placement of gravel fill with no binder	
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	Top fairly level Old access roadway on top of left embankment, approximately 18' wide	
RIPRAP FAILURES	None observed	Riprap placed along lake edge of the left embankment, mostly large pieces of old concrete pavement.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Satisfactory on both sides of spillway	Recently regraded and compacted (1977)
ANY NOTICEABLE SEEPAGE	Lower portions damp on both sides of spillway. Left embankment looks more critical.	Some dampness possibly tidal.
STAFF GAGE AND RECORDER	Wheaton Plastics has depth gage for monitoring flow over spillway.	
DRAINS	None observed	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Old concrete at powerhouse intake a structure cracked and spalled.	Constructed 1920
INTAKE STRUCTURE	2 - 24"ϕ vertical lift sluicegates with iron trashracks for powerhouse intake.	Operating mechanisms overhauled 1978
OUTLET STRUCTURE	Submerged	
OUTLET CHANNEL	None	Main channel of river.
EMERGENCY GATE	4' wide ice gate - lowers to open timber ratchet-operated gate	Good condition Relieves ice condition about power intakes

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Rebuilt 1978. 3 - 48"ϕ RCP replaced 3 existing cast iron pipes up to masonry wall poured slab over pipes. Existing cast iron pipes remain through old masonry wall (see plans for invert elevation).	Filled in sinkholes with stone, poured 3 - 4' thick concrete apron to approximately 60' downstream from spillway. Compacted clay core over pipes upstream of wall.
APPROACH CHANNEL	None - Dam situated right on reservoir boundry.	
DISCHARGE CHANNEL	Great Egg Harbor River 10'-15' deep (tidal) 6'-7' variation	
BRIDGE AND PIERS	3 span bridge 500' downstream of spillway, built 1939. Bridge shifted several inches downstream.	Maximum high tide inundates superstructure soffit.

GATED SPILLWAY @ POWERHOUSE

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Cracked - poor condition	
APPROACH CHANNEL	None	
DISCHARGE CHANNEL	Discharges into main river channel immediately to right of main spillway.	
BRIDGE AND PIERS	See previous page	
GATES AND OPERATION EQUIPMENT	Vertical lift wheel - operated gates	Recently overhauled and in good condition.

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	Wheaton Plastics has depth gauge for monitoring level over spillway crest.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Very flat Maximum depth approximately 30' in center of lake	
SEDIMENTATION	Minor - water action through 3 - 48" pipes keeps area clear in front of spillway	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Clear - average depth 10 - 15' (tidal) Heavily wooded flood plain immediately downstream of bridge Bridge deck approximately 10' below spillway crest elevation	
SLOPES	Moderate - tidal channel	
APPROXIMATE NO. OF HOMES AND POPULATION	Wheaton Plastics Corp. and several blocks of town would be flooded Estimated number of homes = 30 (100 people)	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	Available *
REGIONAL VICINITY MAP	Available *
CONSTRUCTION HISTORY	1977-78 Reconstruction information available
TYPICAL SECTIONS OF DAM	Available *
HYDROLOGIC/HYDRAULIC DATA	Available *
OUTLETS - PLAN	Partial plans available
- DETAILS	Available
-CONSTRAINTS	Not available
-DISCHARGE RATINGS	Available
RAINFALL/RESERVOIR RECORDS	Not available

* N.J.D.E.P.

ITEM	REMARKS
DESIGN REPORTS	Not available
GEOLOGY REPORTS	None available
DESIGN COMPUTATIONS	Available *
HYDROLOGY & HYDRAULICS	Available *
DAM STABILITY	Available *
SEEPAGE STUDIES	Available *
MATERIALS INVESTIGATIONS	Not available
BORING RECORDS	Not available
LABORATORY	Not available
FIELD INVESTIGATIONS	Available *
POST-CONSTRUCTION SURVEYS OF DAM	
BORROW SOURCES.	For original construction - unknown For 1977 Reconstruction - known

*N.J.D.E.P.

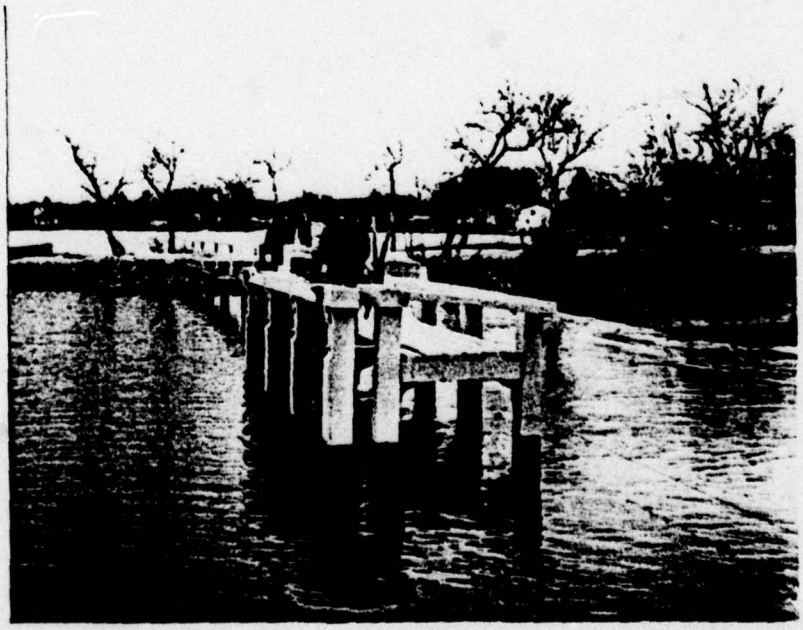
ITEM	REMARKS
MONITORING SYSTEMS	None
MODIFICATIONS	Available
HIGH POOL RECORDS	
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Recent material available *
PRIOR ACCIDENTS OR FAILURE OF DAM	Known
DESCRIPTION	--
REPORTS	None
MAINTENANCE OPERATION RECORDS	Available

* N.J.D.E.P.

ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS	Available
DETAILS	Available
OPERATING EQUIPMENT PLANS & DETAILS	Some available

View of spillway and East embankment

12/78



Operating controls for 3-48"Ø RCP

12/78

4' wide ice gate

12/78

Powerhouse and West embankment from bridge

12/78

Highway bridge 500' downstream from spillway

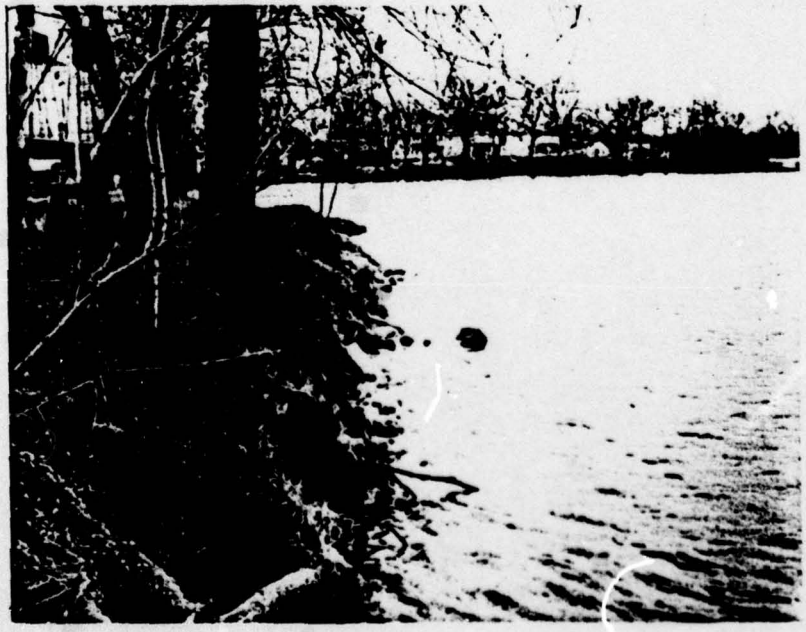
12/78

View of downstream channel from highway bridge

12/78

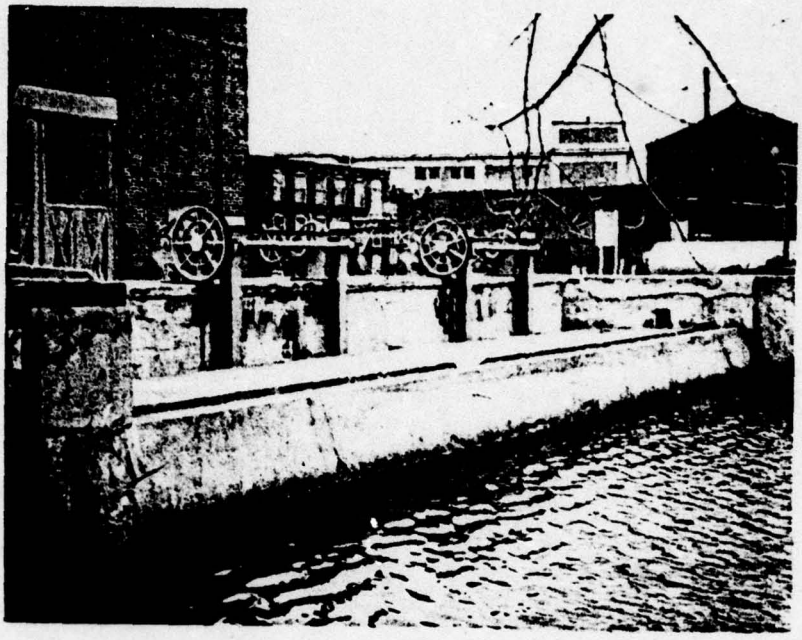
Wheaton Plastics buildings below spillway

12/78



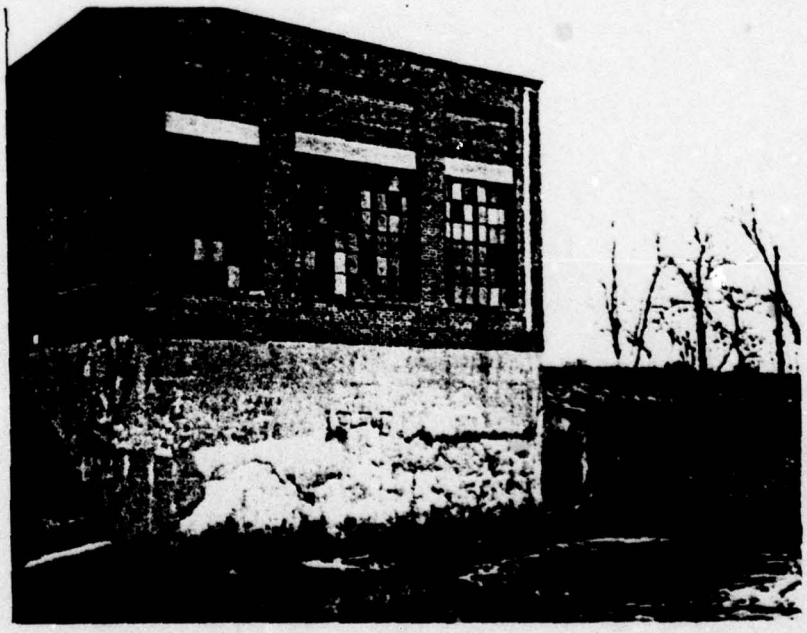
Lakeside embankment right of spillway

12/78



Vertical lift gates for 2-24"Ø pipes to powerhouse

12/78



Old powerhouse with ice gate discharge at right

12/78

DAM NO. NJ 00450

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: AREA = 205 Sq. Mi.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 11.81 (M.S.L.) 4500 acre-ft.

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 16.0 (M.S.L.) 6300 acre-ft.

ELEVATION MAXIMUM DESIGN POOL: 16.25 (earlier report)

ELEVATION TOP DAM: 16.0 ± (varies)

CREST: Spillway

a. Elevation 11.81 (M.S.L.)
b. Type Straight Stone Wall
c. Width 4'
d. Length 124'
e. Location Spillover Entire Length
f. Number and Type of Gates None

OUTLET WORKS: 3 @ 48" ϕ RCP, 2 @ 24" ϕ, 4' Wide Ice Gate

a. Type Vertical Lift Hand Operated Gates
b. Location Spillway Face, Powerhouse, adjacent to Powerhouse
c. Entrance inverts -1.7' M.S.L.
d. Exit inverts -1.7' M.S.L.
e. Emergency draindown facilities 3 - 48" ϕ Lines

HYDROMETEOROLOGICAL GAGES: Wheaton Plastics has depth gage for flow over spillway

a. Type
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE: 4000 cfs

BY. D. J. M. DATE 12-75 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A1 OF...

CHKD. BY..... DATE..... LAKE LENAPE DAM INSPECTION PROJECT 5226

SUBJECT HYDROLOGIC DATA FOR HEC-1 INPUT

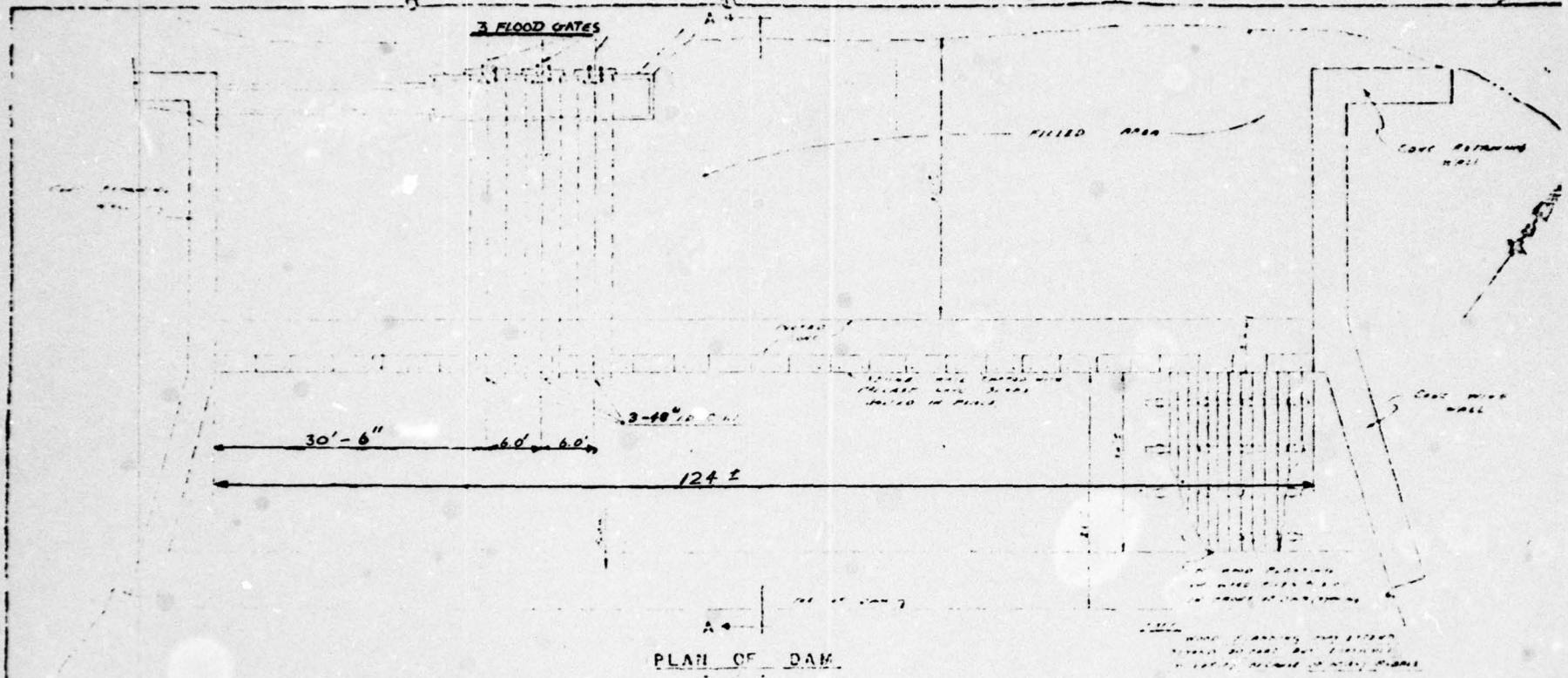
SNYDER COEFFICIENTS (OBTAINED FROM CORPS OF ENGINEERS)

t_p = 66 hours

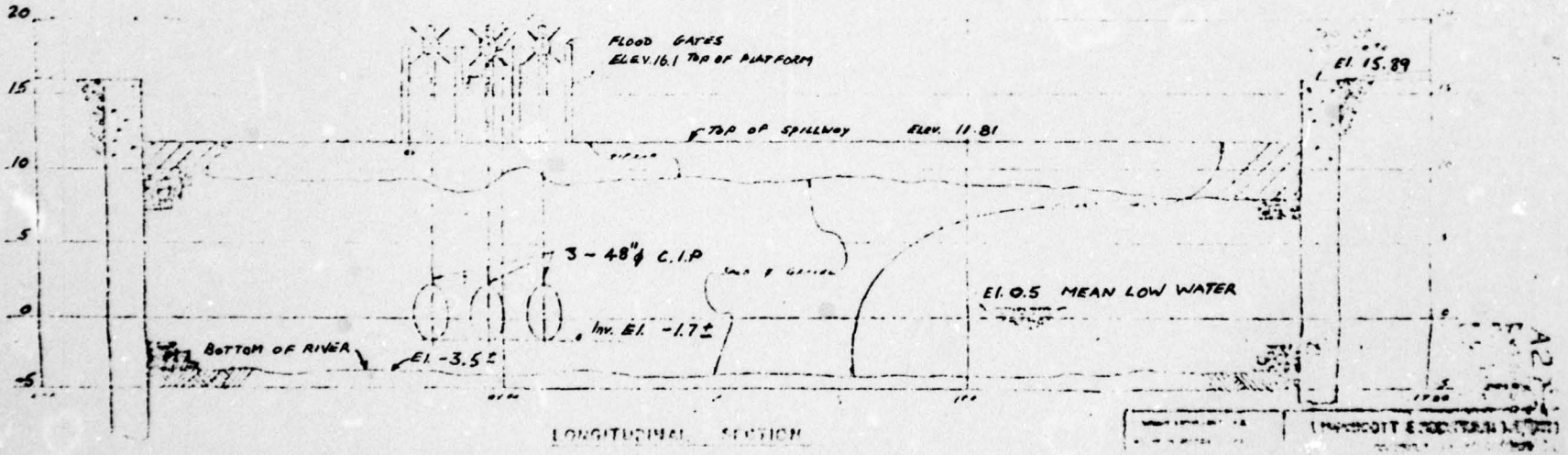
C_p = 0.65

PRECIPITATION DATA (FROM HYDROMETEOROLOGICAL REPORT #33)

P.M.P For 24 hours & 200 sq miles	≈ 24.5
Max 6 hour percentage	= 82%
Max 12 hour percentage	= 90%
Max 24 hour percentage	= 100%
Max 48 hour percentage	= 115%



PLAN OF DAM



LONGITUDINAL SECTION

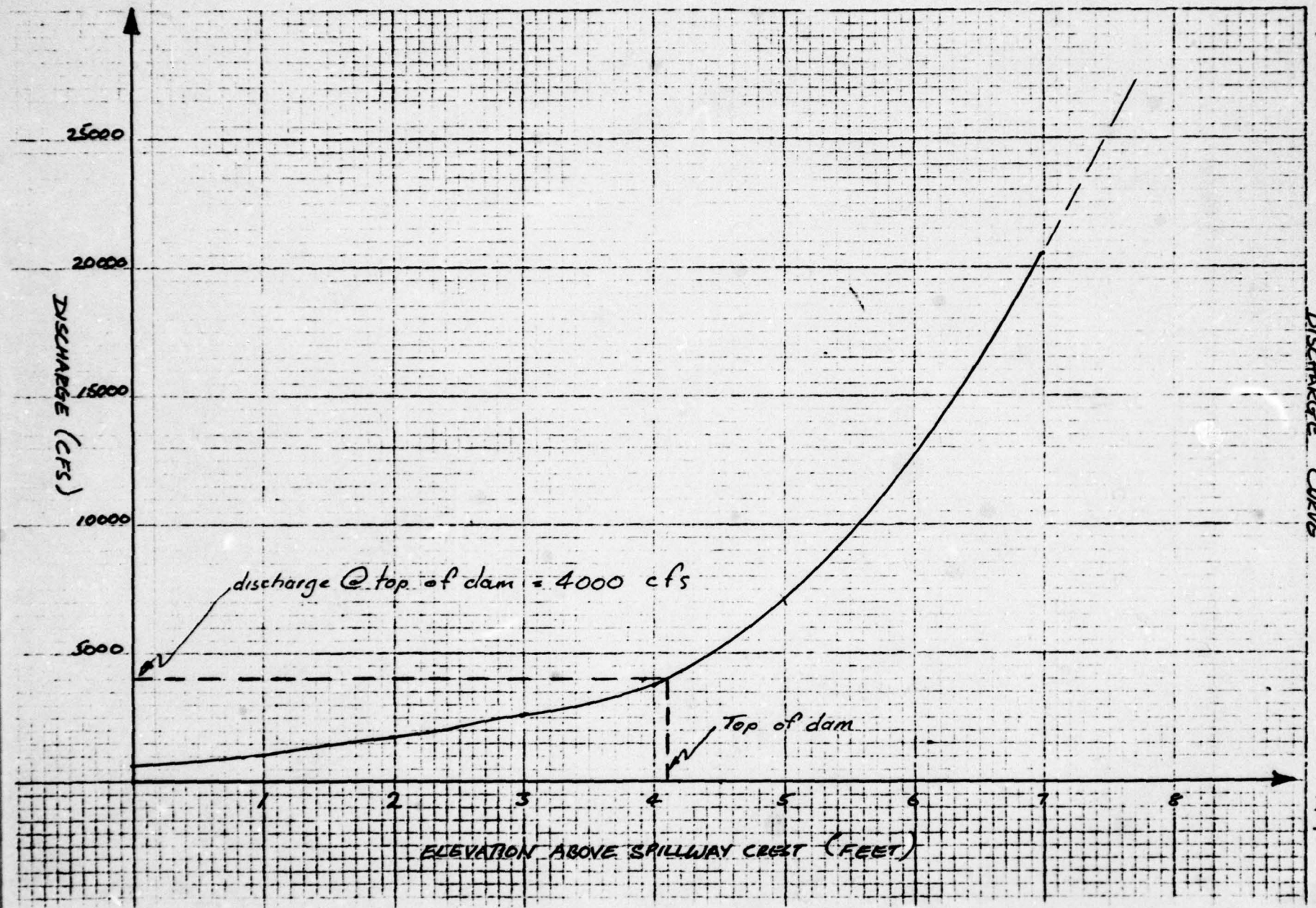
BY. D. J. M DATE 12-78 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A3 OF...

CHKD. BY..... DATE..... LAKE LENAPE DAM INSPECTION PROJECT. C226

SUBJECT Spillway discharge

	Spillway over crest L = 112'			Spillway under sluice controls L = 12'			Over Banks L = 930'			Third sluices * Q = Ca $\sqrt{2gH}$			Σ Q
H	C	Q	H	C	Q	H	C	Q	H	C	Q	
1	3.0	336	1	2.8	34				11.5	0.59	604	974
2	3.0	950	2	2.8	95				12.5	0.59	631	1,676
3	3.0	1746	3	2.8	175				13.5	0.59	655	2,576
4	3.0	2688	4	2.8	269				14.5	0.59	679	3,636
5	3.0	3757	5	2.8	376	0.9	2.8	2223	15.5	0.59	702	7,058
6	3.0	4938	6	2.8	494	1.9	2.8	6820	16.5	0.59	725	12,977
7	3.0	6223	7	2.8	622	2.9	2.8	12860	17.5	0.59	746	20,451
8	3.0	7603	8	2.8	760	3.9	2.8	20056	18.5	0.59	767	29,186
9	3.0	9072	9	2.8	907	4.9	2.8	28245	19.5	0.59	789	39,013
10	3.0	10625	10	2.8	1062	5.9	2.8	37318	20.5	0.59	808	49,813

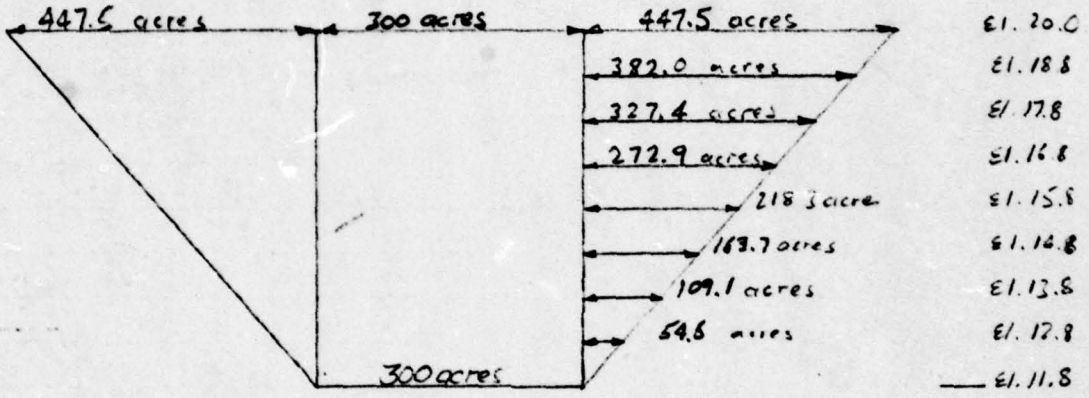
* Assumes 3' tailwater


DISCHARGE CURVE
DISCHARGE (CFS)
25000
20000
15000
10000
5000
discharge @ top of dam = 4000 cfs
Top of dam
1
2
3
4
5
6
7
8
ELEVATION ABOVE SPILLWAY CREST (FEET)

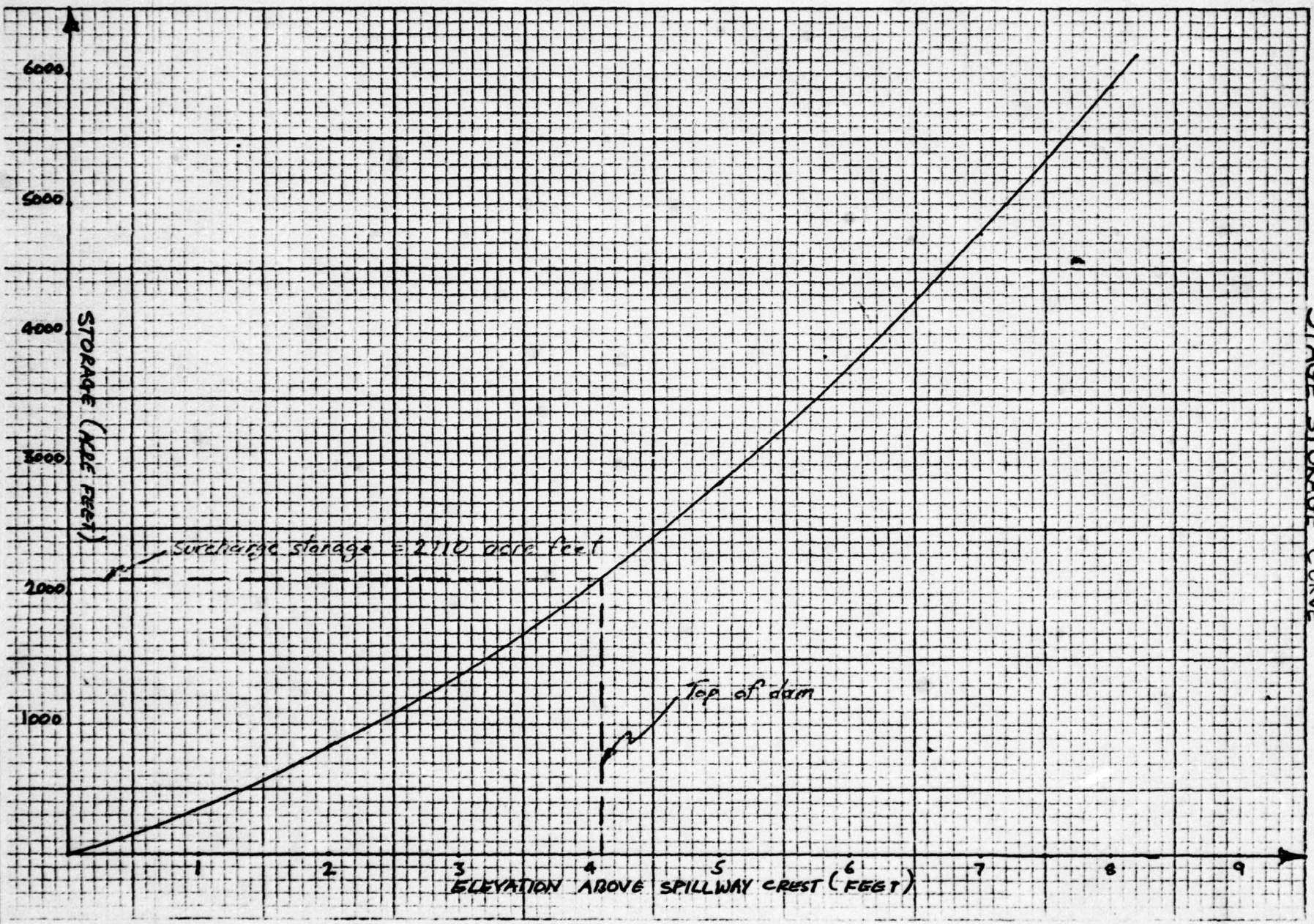
BY D.J.M DATE 12-78 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A5 OF...
CHKD. BY ..... DATE ..... LENAPE LAKE DAM INSPECTION PROJECT C226
SUBJECT ..... SURCHARGE STORAGE

AREA OF LAKE ≈ 300 Acres @ El. 11.8

AREA OF CONTOUR ≈ 1195 Acres @ El. 20.0



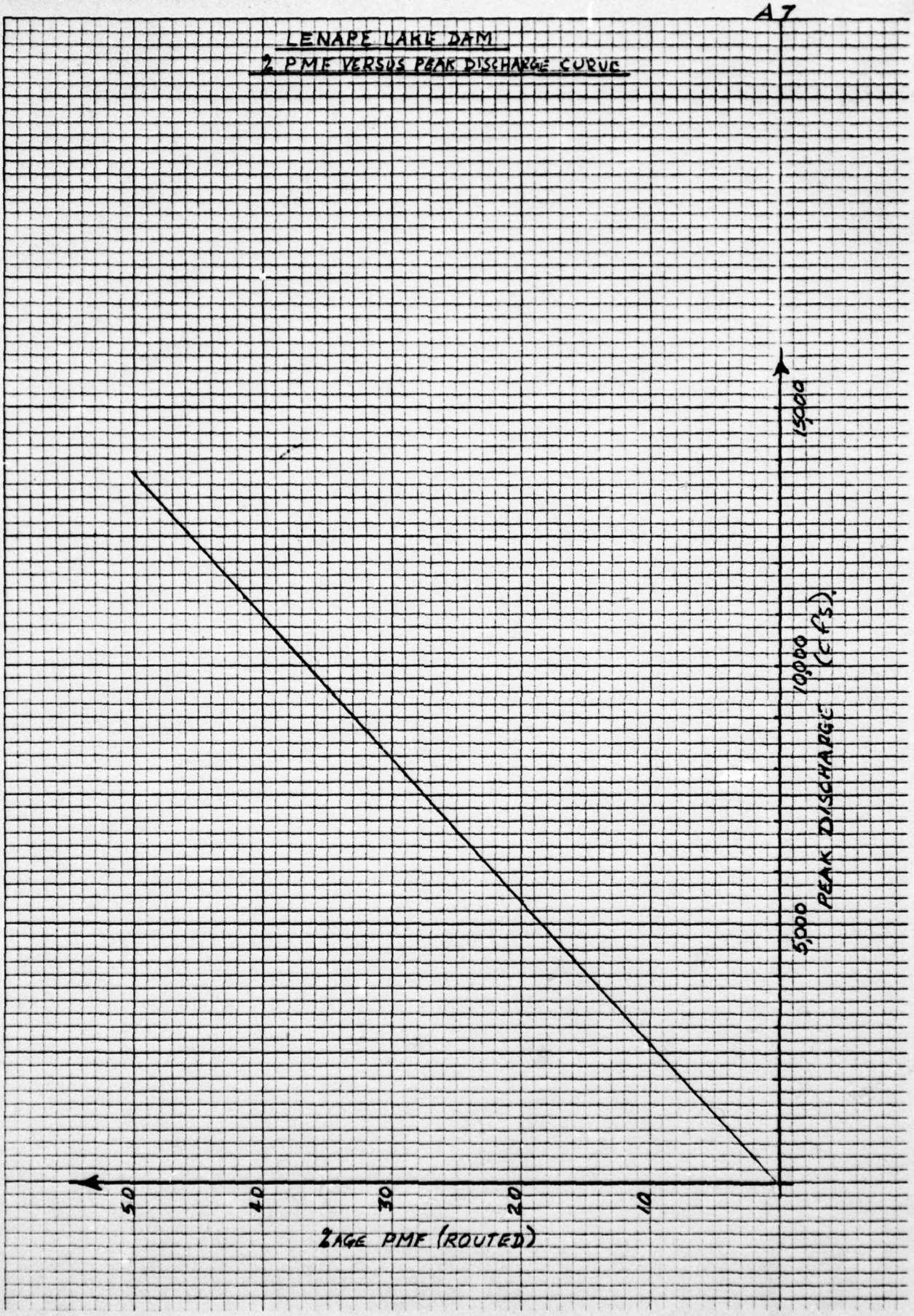
Elev. above spillway (ft)	Storage (acre feet)
1.0	354.6
2.0	818.2
3.0	1391.1
4.0	2073.2
5.0	2864.5
6.0	3764.4
7.0	4774.0
8.2	6129.5



STAGE STORAGE CURVE

LENAPE LAKE DAM

2. PMF VERSUS PEAK DISCHARGE CURVE



BY D.J.M DATE 12-78 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A8 OF...
CHKD. BY ..... DATE ..... LAKE LENAPE DAM INSPECTION PROJECT C226
SUBJECT APPROXIMATE DRAWDOWN CALCULATIONS

Top of spillway crest to pipe invert ≈ 13.5'

Assume sides vertical Vol = 300 × 13.5 acre ft.

= 4050 acre ft.

assume drawdown in 3 stages

Stage 1 Vol = $4050 \times \frac{1}{3}$ Head = 11.25'

Discharge ≈ 600 cfs

$$\text{time (hours)} = \frac{4050 \times 43560}{600 \times 3 \times 3600} \approx 27 \text{ hours}$$

Stage 2 Vol as before Head = 6.75'

Discharg ≈ 430 cfs

$$\text{time (hours)} = \frac{4050 \times 43560}{430 \times 3 \times 3600} \approx 38 \text{ hours}$$

Stage 3 Vol as before Head = 2.25'

Discharge ≈ 230 cfs

$$\text{time (hours)} = \frac{4050 \times 43560}{230 \times 3 \times 3600} = 71 \text{ hours}$$

Σ time ≈ 136 hours ≈ 6 days

LENAPE LAKE DAM INSPECTION SOUTH GROUP C226
BY D.J.MULLIGAN
DECEMBER 1978

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
150	6	0	0	0	0	0	0	0	0

JOPER	NWT
5	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1
RTIOS= 1.00 0.50 0.20 0.10

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH FOR PMF

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
2	0	0	0	1	0	1

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	205.00	0.0	205.00	0.0	0.0	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	P96
0.0	24.50	82.00	90.00	100.00	115.00	0.0	0.0

TRSPC COMPUTED BY THE PROGRAM IS 0.883

LOSS DATA

STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.0	0.0	1.00	0.0	0.0	1.00	0.50	0.10	0.0	0.0

UNIT HYDROGRAPH DATA
TP= 66.00 CP=0.65 NTA= 0

RECESSION DATA
STRTQ= 0.0 QRCSN= 0.0 RTIOR= 1.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=12.37 AND R= 9.55 INTERVALS

UNIT HYDROGRAPH 58 END-OF-PERIOD ORDINATES, LAG= 66.65 HOURS, CP= 0.65 VOL= 1.00

36.	133.	270.	428.	599.	778.	956.	1108.	1221.	1295.
1329.	1319.	1245.	1128.	1016.	915.	824.	741.	668.	601.
541.	487.	439.	395.	356.	320.	288.	259.	234.	210.
189.	171.	154.	138.	124.	112.	101.	91.	82.	74.
66.	60.	54.	48.	44.	39.	35.	32.	29.	26.
23.	21.	19.	17.	15.	14.	12.	11.		

END-OF-PERIOD FLOW

TIME	RAIN	EXCS	COMP Q

LOUIS BERGER & ASSOCIATES INC.
BY D.J.M. DATE
CHKD. BY DATE
SUBJECT LENAPE LAKE DAM
PROJECT
SHEET NO 49 OF

1	0.13	0.00	0.
2	0.26	0.00	0.
3	2.66	1.97	71.
4	0.19	0.00	263.
5	0.87	0.27	542.
6	1.73	1.13	920.
7	17.74	17.14	2016.
8	1.30	0.70	4262.
9	0.0	0.0	7245.
10	0.0	0.0	10586.
11	0.0	0.0	14102.
12	0.0	0.0	17685.
13	0.0	0.0	21120.
14	0.0	0.0	23979.
15	0.0	0.0	25968.
16	0.0	0.0	27124.
17	0.0	0.0	27513.
18	0.0	0.0	27044.
19	0.0	0.0	25420.
20	0.0	0.0	23062.
21	0.0	0.0	20769.
22	0.0	0.0	18699.
23	0.0	0.0	16835.
24	0.0	0.0	15157.
25	0.0	0.0	13647.
26	0.0	0.0	12287.
27	0.0	0.0	11062.
28	0.0	0.0	9959.
29	0.0	0.0	8967.
30	0.0	0.0	8073.
31	0.0	0.0	7268.
32	0.0	0.0	6544.
33	0.0	0.0	5892.
34	0.0	0.0	5305.
35	0.0	0.0	4776.
36	0.0	0.0	4300.
37	0.0	0.0	3871.
38	0.0	0.0	3485.
39	0.0	0.0	3138.
40	0.0	0.0	2825.
41	0.0	0.0	2544.
42	0.0	0.0	2290.
43	0.0	0.0	2062.
44	0.0	0.0	1856.
45	0.0	0.0	1671.
46	0.0	0.0	1505.
47	0.0	0.0	1355.
48	0.0	0.0	1220.
49	0.0	0.0	1098.
50	0.0	0.0	989.
51	0.0	0.0	890.
52	0.0	0.0	801.
53	0.0	0.0	722.
54	0.0	0.0	650.
55	0.0	0.0	585.
56	0.0	0.0	527.
57	0.0	0.0	474.
58	0.0	0.0	427.
59	0.0	0.0	384.
60	0.0	0.0	346.
61	0.0	0.0	292.

BY D.J.M DATE

CHKD. BY DATE

SUBJECT

LOUIS BERGER & ASSOCIATES INC.

LENAPE LAKE DAM

SHEET NO. A11 OF

PROJECT

62	0.0	0.0	263.
63	0.0	0.0	234.
64	0.0	0.0	199.
65	0.0	0.0	8.
66	0.0	0.0	0.
67	0.0	0.0	0.
68	0.0	0.0	0.
69	0.0	0.0	0.
70	0.0	0.0	0.
71	0.0	0.0	0.
72	0.0	0.0	0.
73	0.0	0.0	0.
74	0.0	0.0	0.
75	0.0	0.0	0.
76	0.0	0.0	0.
77	0.0	0.0	0.
78	0.0	0.0	0.
79	0.0	0.0	0.
80	0.0	0.0	0.
81	0.0	0.0	0.
82	0.0	0.0	0.
83	0.0	0.0	0.
84	0.0	0.0	0.
85	0.0	0.0	0.
86	0.0	0.0	0.
87	0.0	0.0	0.
88	0.0	0.0	0.
89	0.0	0.0	0.
90	0.0	0.0	0.
91	0.0	0.0	0.
92	0.0	0.0	0.
93	0.0	0.0	0.
94	0.0	0.0	0.
95	0.0	0.0	0.
96	0.0	0.0	0.
97	0.0	0.0	0.
98	0.0	0.0	0.
99	0.0	0.0	0.
100	0.0	0.0	0.
101	0.0	0.0	0.
102	0.0	0.0	0.
103	0.0	0.0	0.
104	0.0	0.0	0.
105	0.0	0.0	0.
106	0.0	0.0	0.
107	0.0	0.0	0.
108	0.0	0.0	0.
109	0.0	0.0	0.
110	0.0	0.0	0.
111	0.0	0.0	0.
112	0.0	0.0	0.
113	0.0	0.0	0.
114	0.0	0.0	0.
115	0.0	0.0	0.
116	0.0	0.0	0.
117	0.0	0.0	0.
118	0.0	0.0	0.
119	0.0	0.0	0.
120	0.0	0.0	0.
121	0.0	0.0	0.
122	0.0	0.0	0.

125	0.0	0.0	0.
126	0.0	0.0	0.
127	0.0	0.0	0.
128	0.0	0.0	0.
129	0.0	0.0	0.
130	0.0	0.0	0.
131	0.0	0.0	0.
132	0.0	0.0	0.
133	0.0	0.0	0.
134	0.0	0.0	0.
135	0.0	0.0	0.
136	0.0	0.0	0.
137	0.0	0.0	0.
138	0.0	0.0	0.
139	0.0	0.0	0.
140	0.0	0.0	0.
141	0.0	0.0	0.
142	0.0	0.0	0.
143	0.0	0.0	0.
144	0.0	0.0	0.
145	0.0	0.0	0.
146	0.0	0.0	0.
147	0.0	0.0	0.
148	0.0	0.0	0.
149	0.0	0.0	0.
150	0.0	0.0	0.
SUM	24.88	21.21	465173.

	PEAK	10-DAY	30-DAY	90-DAY	TOTAL VOLUME
CFS	27513.	11298.	3876.	3101.	465172.
INCHES		20.51	21.11	21.11	21.11
AC-FT		224205.	230783.	230783.	230783.

HYDROGRAPH AT STA 2 FOR PLAN 1, RTIO 1

0.	0.	71.	263.	542.	920.	2016.	4262.	7245.	10586.
14102.	17685.	21120.	23979.	25968.	27124.	27513.	27044.	25420.	23062.
20769.	18699.	16835.	15157.	13647.	12287.	11062.	9959.	8967.	8073.
7268.	6544.	5892.	5305.	4776.	4300.	3871.	3465.	3138.	2825.
2544.	2290.	2062.	1856.	1671.	1505.	1355.	1220.	1098.	989.
890.	801.	722.	650.	585.	527.	474.	427.	384.	346.
292.	263.	234.	199.	8.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	10-DAY	30-DAY	90-DAY	TOTAL VOLUME
CFS	27513.	11298.	3876.	3101.	465172.
INCHES		20.51	21.11	21.11	21.11
AC-FT		224205.	230783.	230783.	230783.

HYDROGRAPH AT STA 2 FOR PLAN 1, RTIO 2

0.	0.	35.	131.	271.	460.	1008.	2131.	3622.	5293.
7051.	8842.	10560.	11990.	12984.	13562.	13757.	13522.	12710.	11531.

BY D.J.M. DATE........ **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A13 OF...

CHKD. BY...... DATE........ LENAPE LAKE DAM PROJECT..........

SUBJECT..........

10385.	9350.	8418.	7579.	6823.	6143.	5531.	4980.	4483.	4037.
3634.	3272.	2946.	2652.	2388.	2150.	1936.	1743.	1569.	1413.
1272.	1145.	1031.	928.	836.	752.	677.	610.	549.	494.
445.	401.	361.	325.	292.	263.	237.	213.	192.	173.
146.	131.	117.	100.	4.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	10-DAY	30-DAY	90-DAY	TOTAL VOLUME
CFS	13757.	5649.	1938.	1551.	232585.
INCHES		10.25	10.55	10.55	10.55
AC-FT		112102.	115391.	115391.	115391.

HYDROGRAPH AT STA 2 FOR PLAN 1, RTIO 3

0.	0.	14.	53.	108.	184.	403.	652.	1449.	2117.
2820.	3537.	4224.	4796.	5194.	5425.	5503.	5409.	5084.	4612.
4154.	3740.	3367.	3031.	2729.	2457.	2212.	1992.	1793.	1615.
1454.	1309.	1178.	1061.	955.	860.	774.	697.	626.	565.
509.	458.	412.	371.	334.	301.	271.	244.	220.	198.
178.	160.	144.	130.	117.	105.	95.	85.	77.	69.
58.	53.	47.	40.	2.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	10-DAY	30-DAY	90-DAY	TOTAL VOLUME
CFS	5503.	2260.	775.	620.	93033.
INCHES		4.10	4.22	4.22	4.22
AC-FT		44841.	46156.	46156.	46156.

HYDROGRAPH AT STA 2 FOR PLAN 1, RTIO 4

0.	0.	7.	26.	54.	92.	202.	426.	724.	1059.
1410.	1768.	2112.	2398.	2597.	2712.	2751.	2704.	2542.	2306.
2077.	1870.	1684.	1516.	1365.	1229.	1106.	996.	897.	807.
727.	654.	589.	530.	478.	430.	387.	349.	314.	283.
254.	229.	206.	186.	167.	150.	135.	122.	110.	99.
89.	80.	72.	65.	58.	53.	47.	43.	38.	35.
29.	26.	23.	20.	1.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	10-DAY	30-DAY	90-DAY	TOTAL VOLUME
CFS	2751.	1130.	388.	310.	46517.
INCHES		2.05	2.11	2.11	2.11

AC-FT			22421.	23078.	23078.		23078.			

HYDROGRAPH ROUTING

ROUTING THROUGH RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
22	1	0	0	1	0	1

ROUTING DATA

GLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.0	0.0	1	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.0	0.0	0.0	0.

STORAGE=	0.	818.	1391.	2073.	2864.	3764.	4774.	5900.	7123.	8460.
OUTFLOW=	0.	1676.	2576.	3636.	7058.	12977.	20451.	29186.	39013.	49813.

STATION 22, PLAN 1, RTIO 1

0.	0.	24.	120.	310.	594.	1183.	2362.	4779.	9457.
13039.	16734.	20186.	23291.	25505.	26875.	27459.	27222.	25920.	23711.
21348.	19244.	17332.	15603.	14048.	12662.	11437.	10289.	9265.	8341.
7510.	6810.	6197.	5577.	5021.	4521.	4070.	3665.	3455.	3192.
2910.	2635.	2378.	2143.	1931.	1739.	1543.	1371.	1228.	1104.
993.	894.	805.	724.	652.	587.	529.	476.	429.	386.
341.	298.	264.	232.	145.	50.	16.	5.	2.	1.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STOR

0.	0.	12.	59.	152.	290.	577.	1255.	2337.	3229.
3772.	4272.	4738.	5140.	5425.	5602.	5677.	5647.	5479.	5194.
4890.	4611.	4353.	4119.	3909.	3716.	3530.	3355.	3200.	3059.
2933.	2807.	2665.	2522.	2393.	2278.	2173.	2080.	1957.	1787.
1606.	1429.	1265.	1116.	980.	858.	753.	669.	599.	539.
485.	436.	393.	354.	318.	287.	258.	232.	209.	188.
166.	145.	129.	113.	71.	24.	8.	3.	1.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	10-DAY	30-DAY	90-DAY	TOTAL VOLUME
CFS	27459.	11285.	3876.	3101.	465172.
INCHES		20.48	21.11	21.11	21.11
AC-FT		223954.	230783.	230783.	230783.

STATION 22, PLAN 1, RTIO 2

BY D.J.M. DATE
CHKD. BY DATE
SUBJECT LENAPE LAKE DAM

LOUIS BERGER & ASSOCIATES INC.

SHEET NO. A14 OF
PROJECT

0.	0.	12.	60.	155.	297.	591.	1250.	2234.	3474.
6127.	8199.	10061.	11566.	12708.	13428.	13728.	13613.	12970.	11917.
10728.	9661.	8697.	7831.	7051.	6463.	5815.	5236.	4714.	4244.
3821.	3531.	3296.	3020.	2742.	2476.	2234.	2013.	1813.	1623.
1434.	1282.	1151.	1036.	932.	839.	755.	680.	612.	551.
496.	447.	402.	362.	326.	294.	264.	238.	214.	193.
170.	149.	132.	116.	73.	25.	8.	3.	1.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STOR

0.	0.	6.	29.	76.	145.	289.	610.	1173.	1968.
2649.	3037.	3321.	3549.	3723.	3825.	3865.	3850.	3763.	3603.
3422.	3260.	3113.	2981.	2862.	2727.	2577.	2443.	2322.	2214.
2116.	2005.	1854.	1676.	1498.	1329.	1173.	1032.	905.	792.
700.	626.	562.	505.	455.	410.	369.	332.	299.	269.
242.	218.	196.	177.	159.	143.	129.	116.	105.	94.
83.	73.	65.	57.	36.	12.	4.	1.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

		PEAK	10-DAY	30-DAY	50-DAY	TOTAL VOLUME
	CFS	13728.	5643.	1938.	1551.	232585.
	INCHES		10.24	10.55	10.55	10.55
	AC-FT		111981.	115391.	115391.	115391.

STATION 22. PLAN 1. RTIO 3

0.	0.	5.	24.	62.	119.	237.	500.	938.	1508.
2075.	2693.	3353.	4307.	5019.	5319.	5469.	5455.	5239.	4835.
4367.	3932.	3584.	3370.	3098.	2817.	2549.	2298.	2071.	1865.
1680.	1479.	1320.	1185.	1066.	959.	863.	777.	700.	630.
567.	511.	460.	414.	375.	338.	302.	272.	245.	221.
199.	179.	161.	145.	130.	117.	106.	95.	66.	77.
69.	60.	53.	46.	29.	10.	3.	1.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STOR

0.	0.	2.	12.	30.	58.	115.	244.	458.	736.
1072.	1466.	1891.	2228.	2393.	2462.	2497.	2494.	2444.	2350.
2242.	2141.	2040.	1902.	1727.	1546.	1374.	1214.	1069.	938.
820.	722.	644.	578.	520.	468.	421.	379.	342.	308.
277.	249.	224.	202.	182.	164.	147.	133.	120.	108.

BY D.J.M DATE________ **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A16 OF__

CHKD. BY______DATE________ LENAPE LAKE DAM PROJECT____________

SUBJECT____________

97.	87.	79.	71.	64.	57.	52.	46.	42.	36.
33.	29.	26.	23.	14.	5.	2.	1.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	10-DAY	30-DAY	90-DAY	TOTAL VOLUME
CFS	5469.	2257.	775.	620.	93033.
INCHES		4.10	4.22	4.22	4.22
AC-FT		44792.	46156.	46156.	46156.

STATION 22, PLAN 1, RTIO 4

0.	0.	2.	12.	31.	59.	118.	250.	469.	754.
1078.	1422.	1755.	2035.	2294.	2496.	2628.	2684.	2650.	2524.
2338.	2133.	1933.	1746.	1554.	1381.	1237.	1112.	1000.	900.
811.	730.	657.	592.	533.	479.	432.	389.	350.	315.
284.	255.	230.	207.	186.	168.	151.	136.	122.	110.
99.	89.	80.	72.	65.	59.	53.	48.	43.	39.
34.	30.	26.	23.	15.	5.	2.	1.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STOR

0.	0.	1.	6.	15.	29.	58.	122.	229.	368.
526.	694.	868.	1047.	1212.	1340.	1424.	1460.	1439.	1358.
1237.	1109.	982.	863.	759.	674.	604.	543.	488.	439.
396.	356.	321.	289.	260.	234.	211.	190.	171.	154.
138.	125.	112.	101.	91.	82.	74.	66.	60.	54.
48.	44.	39.	35.	32.	29.	26.	23.	21.	19.
17.	15.	13.	11.	7.	2.	1.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	10-DAY	30-DAY	90-DAY	TOTAL VOLUME
CFS	2684.	1129.	388.	310.	46517.
INCHES		2.05	2.11	2.11	2.11
AC-FT		22396.	23078.	23078.	23078.

PEAK FLOW SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS

			RATIOS APPLIED TO FLOWS			
OPERATION	STATION	PLAN	1.00	0.50	0.20	0.10
HYDROGRAPH AT	2	1	27513.	13757.	5503.	2751.
		2	**********	**********	**********	**********
ROUTED TO	22	1	27459.	13728.	5469.	2684.
		2	**********	**********	**********	**********

Wheaton Industries
Lenape Lake Dam - LEA Ref. 1516-A
May 16, 1977
Page One

BACKGROUND

Approximately two years ago our office was contacted regarding a sink hole which had developed in the area above the three pipe spillways at Lenape Lake Dam, the flow to which is controlled by manually operated gate valves. At the time of our inspection, it was our opinion that the earth embankment behind the concrete wall was in danger of being washed or "piped" through an opening in one of the spillway pipes. Subsequently, a meeting was held at Wheaton Plastics. Among those in attendance were representatives from Wheaton Industries, Township of Hamilton, Corps of Engineers, Lake Lenape Land Company, a diver to make a cursory examination of the structure and Lippincott Engineering.

It was our recommendation at this point in time that the lake be lowered to preclude what might be a major failure, and to examine the three spillway pipes. We visually examined what appeared to be the worst portion of the pipes by means of excavating with a backhoe and crawled up each pipe to internally examine the condition of each pipe. One pipe in particular had some longitudinal cracks and separations which were approximately 1 to 1.5 inches in width and 2 to 4 feet in length. Examination further revealed that the pipes were securely embedded in the downstream face of the dam which was identified as a 4 foot concrete wall covered with a 1.5 to 2 foot masonry facing. Because the pipes were securely positioned in the concrete, the possibility

of channelling along the pipe through to the downstream face of the structure is considered remote.

Following this inspection, probes and test borings were taken at our request and revealed the absence of a "heal" to the dam, which prompted us to further examine the structure for its geometric properties so that the dam's stability could be computed. I personally examined the downstream face of the dam below water utilizing scuba gear and found that the supposed "toe" was not integral with the structure rather, it consisted of a system of piles driven approximately 5 feet on center each way with 6" x 6" timber lagged to the top of the piles. A timber deck was fastened to and supported by the timber substructure. Except for an area immediately in front of the 3 spillway pipes the decking appeared to extend some 50 feet downstream of the dam structure. In front of the pipes the decking extended only 20 feet.

Between the individual piles, large rip-rap had been eroded to a depth of 6 feet below the decking. Because of the erosion the face and toe of the dam were accessible beneath the timber decking. As noted on the drawings, the timber sheeting in front of the toe was visable. With this new information and the test borings which indicated a very approximate depth to the bottom of the structure, we re-analyzed the dam for stability as discussed hereafter.

No. it's all masonry

DESCRIPTION OF DAM

The dam is believed to be essentially a 4 foot thick concrete wall faced with masonry having a probable total height dimension of 25 feet (see drawing #3). Approximately 12 feet extend above the planking - the remainder below. The (1) earth embankment upstream of the dam, and (2) the planking, piles and rip-rap core stone mass downstream are integral to the entire structure and are required in order to maintain the structural stability.

HYDROLOGIC STUDY

It should be recognized that we did not perform a rigorous hydrologic analysis; rather we used USGS maps to delineate the watershed and computed Q based upon Special Report #38. A comparison was made between the Stankowski method and the rational procedure. An area of approximately 210 SM with a channel distance of 32 miles was used. (See calculation sheets).

The capacity of the principal spillway without allowing freeboard is approximately 3100 cfs. The Bureau has used a design capacity based on a 100 year frequency storm. Based upon our estimates, we find that the quantity of discharge for a 100 year storm is between 3200 and 4400 cfs, depending upon methods of analysis used and parameters assumed (see analysis). It is our opinion that a figure closer to 4 00 cfs is reasonable for a [illegible] storm. Using this figure, a 100 year frequency storm

would overtop the wingwalls by less than 1 inch and the low point along the north dike by about 1.0 feet. We contacted Mr. William Rogers, P.E., hydrologist at the New Jersey Department of Water Resources, who informed us that no hydrologic study and very little information was available for areas downstream of the USGS stream gaging station in Folsom, New Jersey. As a point of observation, however, it was reported that the head of water resulting from a heavy storm in September, 1975, was approximately 3.5 feet at that station. We have been informed that that storm was equivalent to a 10 year frequency as measured at the Folsom gaging station. Therefore, it might be concluded that a 100 year frequency storm would overtop the abutments, but a clear determination would have to be based on a detailed examination of the watershed so that an accurate inflow-outflow hydrograph could be constructed. A discharge curve for the principal and secondary spillways is included in the appendix.

STABILITY ANALYSIS

The stability of the structure for sliding and overturning about its toe was analyzed. For analysis we assumed a four foot (top of wing walls) head of water at the spillway crest. Topographical and profile information from Price Engineering Company and that which we outlined during our mutual investigation on the 7th of 1975, revealed that the lowest point exists along the [illegible] which is approximately [illegible] feet above the principal spillway invert.

spillway (see Drawing #1).

The underwater reconnaissance performed by our office was utilized to further define the specific details of the structure at least to the extent to which a visual examination could be made. A sketch of the cross-section is shown on Sheet #3. Although the bottom of the masonry structure was not exposed, probes indicated it is founded at about elevation minus 13.

The intent of the stability analysis was to check the dam for:

a. overturning

b. sliding

c. bearing capacity failure at the toe

d. boiling due to heave at the toe

The above analysis was performed utilizing a four foot [illegible] above the crest of the principal spillway, i.e. El. 15.8, and [illegible] water elevation of +19.8. It is recognized that the earth dam will be elevated prior to the lake reaching this height but it was used for analysis purposes.

Analysis of the stability of the structure, neglecting the effect of the piling structure at its toe, (which is much too conservative) indicates that the dam has a factor of safety [illegible] with a four foot head over the spillway crest. It [illegible] that the original intent of the design was to include [illegible] effects of the piling structure and repeat [illegible]

[illegible]

though it is somewhat indeterminate. It is recognized that the interaction of timber piling, decking, support structure and interlocking stone give continuity, integrity and stability. The total mass acts as a pivital point about which the dam would have to rotate. As such, the structure calculates with an adequate factor of safety in overturning.

A seepage analysis under the masonry structure was performed and we have found that the safety factor for boil at the toe is quite acceptable and not particularly significant. The structure was also analyzed for rotation about the toe. So long as the downstream mass is kept in tact, overturning computes with an adequate factor of safety.

RECOMMENDATIONS FOR REPAIR

The following recommendations are essential to insure the stability of the structure:

a. Place suitable rubble (rip-rap) fill and blanket at toe of dam where erosion has taken place. Fill should extend for a minimum distance of 40 feet.

b. Cap rubble with concrete apron and energy dissipator to reduce potential for future erosion and reduce high velocity thru pipes.

c. Excavate around 3 spillway pipes and encase cracked portions in concrete. Backfill and compact around pipes with suitably placed compacted clay. A clay envelope

below, around and above pipes would preclude propagation of future sink holes.

d. Replace defective control gates and support structure as required.

e. Make an absolute determination as to the depth of the structure by core drilling said structure.

It is recommended that the dike be raised so that it would provide at least one foot of freeboard above the 100 year lake elevation. An alternative would be to construct a second spillway (emergency) at some acceptable location.

CONCLUSIONS

Based upon available information and our analysis, it is believed that the dam structure can be adequately repaired for servicable use. It is difficult to predict the Q and the height to which the lake will rise, but it is believed that the 4000 cfs is a reasonable figure.

No freeboard is available above the wingwalls. Also the dike would be crested by the flow of 4000 cfs. It is assumed that the upstream peak runoff will not materially be altered in the future either in intensity or duration.

It is also noted that upstream dams exist which have manually controlled gates, thus making it more difficult to predict flows. Apparently history has indicated the flows have been handled

adequately by this structure in combination with the 3-48"Ø manually controlled gates.

Two other gates exist on the Wheaton property which were used for the power house and ice. These were not discussed in this report since it is believed that they should not be relied upon.